

Scilab Textbook Companion for
Worked Examples In Engineering In Si Units,
Volume Iii, Electrical Engineering
by M. Bates¹

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Book Description

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

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Chapter 1

circuit analysis

Scilab code Exa 1.1 finding currents using superposition theorem

```
1  clc
2  clear
3
4  //input
5  r1=4; //resistance between point A and B in ohms
        which is in series with 10 volts d.c. supply.
6  r2=3; //resistance between points C and D in ohms
        which is in series with a d.c. supply of 8 volts.
7  r3=5; //resistance between points F and G in ohms
8  //arms AB,CD,FG are in parallel with each other.
9  v1=10; //d.c. supply voltage in the arm AB in volts
10 v2=8; //d.c. supply voltage in the arm CD in volts
11
12 //calculations
13 //using SUPER POSITION THEOREM
14 //voltage source of 8 volts is neglected and supply
        is 10 volts d.c
15 R1=r1+((r2*r3)/(r2+r3)); // total resistance in ohms
16 bIa1=v1/R1; //current in arm AB in amperes
17 cId1=v1*(r3/(R1*(r2+r3))); //current in arm CD in
        amperes
```

```

18 dIc1= -cId1;
19 fIg1=(v1/R1)-cId1;//current in arm FG in amperes
20 //voltage source of 10 volts is neglected and supply
    is 8 volts d.c
21 R2=r2+((r1*r3)/(r1+r3));//total resistance in ohms
22 dIc2=v2/R2;//current in arm CD in amperes
23 aIb2=v2*(r3/(R2*(r3+r1)));//current in arm AB in
    amperes
24 bIa2= -aIb2;
25 fIg2=(v2/R2)-aIb2;//current in arm FG in amperes
26 I1=bIa1+bIa2;//current in 10 V source in amperes
27 I2=dIc1+dIc2;//current in 8V source in amperes
28 I3=fIg1+fIg2;//current in arm FG in amperes
29
30 //output
31 mprintf('the currents in the circuit are %3.5f A %3
    .5f A %3.5f A',I1,I2,I3)

```

Scilab code Exa 1.2 finding thevinins equivalent circuit

```

1 clc
2 clear
3
4 //input
5 v1=10;// d.c. voltage source in volts present in arm
    1 in series with a 2 ohm resistor
6 v2=15;//d.c. voltage source in volts present in arm
    2 in series with a 3 ohm resistor
7 r1=2; //resistance in arm 1 in ohms
8 r2=3; // resistance in arm 2 in ohms
9 r3=1.8; //resistance between node formed by arm 1 and
    2 and point A
10 R=3; //load resistance in ohms placed in arm AB
11 // point A and B are in open condition and arm 1 and
    2 are in parallel

```

```

12
13 //calculations
14 //thevenin equivalent circuit method
15 i1=(v2-v1)/(r1+r2);// current in the parallel
    circuit in amperes
16 e=v2-(i1*r2);// open circuit e.m.f in volts i.e.
    thevenin's voltage
17 r=r3+((r1*r2)/(r1+r2));// resistance to be
    considered between AandB in ohms i.e. thevenin's
    resistance
18 I=e/(r+R);//current through the load resistance in
    amperes
19
20 //output
21 mprintf(' the thevenin equivalent generator will
    have a constant e.m.f. of %3.0f V and internal
    resistance of %3.0f ohm. \n the current in 3 ohm
    resistor is %3.0f A',e,r,I)

```

Scilab code Exa 1.3 finding current in a branch using thevenin's theorem

```

1  clc
2  clear
3
4  //input
5  r1=0.2;//resistance in arm 1 in ohms which is in
    series with 10 volts d.c. supply.
6  r2=0.2;//resistance in arm 2 in ohms which is in
    series with a d.c. supply of 12 volts.
7  r3=0.4;//resistance in arm 3 in ohms which is in
    series with 15 volts d.c. supply .
8  //arms 1,2 and 3 are in parallel with each other and
    are parallel with the arm AB.
9  v1=10;//d.c. supply voltage in the arm 1 in volts
10 v2=12;//d.c. supply voltage in the arm 2 in volts

```

```

11 v3=15; //d.c. supply voltage in the arm 3 in volts
12 R1=2.28; // resistance in arm AB in ohms in one case
13 R2=5.82; // resistance in arm AB in ohms in another
14
15 //calculations
16 //thevenin equivalent circuit method
17 e=((v3/r3)+(v2/r2)+(v1/r1))/((1/r1)+(1/r2)+(1/r3));
    // thevenin's voltage in volts
18 r=1/((1/r1)+(1/r2)+(1/r3)); //thevenin's resistance
    in ohms
19 I1=e/(r+R1); // current when resistance in AB arm is
    2.28 ohms
20 I2=e/(r+R2); // current when resistance in AB arm is
    5.82 ohms
21
22 //output
23 mprintf('the equivalent generator has a constant
    voltage of %3.1f V and an internal resistance of
    %3.2f ohms \n the load currents are %3.0f A and
    %3.0f A',e,r,I1,I2)

```

Scilab code Exa 1.4 finding a current in a branch using thevenins theorem

```

1  clc
2  clear
3
4  //input
5  //AB,BC,CD,DA are arms of a wheatstone bridge
6  r1=4; //resistance in arm AB in ohms
7  r2=6; //resistance in arm BC in ohms
8  r3=5; //resistance in arm CD in ohms
9  r4=3; //resistance in arm DA in ohms
10 v=4; //d.c. supply given between points A and C in
    volt
11 R=10; //resistance of the detector placed between the

```

```

        points B and D in ohms
12
13 //calculations
14 aIb=v/(r1+r2); //current in arm AB in amperes
15 aId=v/(r3+r4); //current in arm DA in amperes
16 aVb=aIb*r1; //voltage drop along arm AB in volts
17 aVd=aId*r4; //voltage drop across arm AD in volts
18 dVb=aVb-aVd; //since D is positive with respect to B
19 e=dVb; // open circuit voltage in volts
20 r0=((r1*r2)/(r1+r2))+((r3*r4)/(r3+r4)); //equivalent
    resistance in ohms when the supply neglected
21 I=e/(r0+R); //current through the 10 ohms resistance
    in amperes
22
23 //output
24 fprintf('the current through the detector will be %3
    .5f A in the direction from D to B',I)

```

Scilab code Exa 1.5 finding current in resistor using nortons theorem

```

1 clc
2 clear
3
4 //input
5 v1=21; //voltage of first battery in arm 1 in volts
6 v2=16; //voltage of second battery in arm 2 in volts
7 r1=3; //internal resistance of first battery in ohms
8 r2=2; //internal resistance of second battery in ohms
9 R=6; //resistance going to be introduced in arm AB in
    ohms
10 //arms 1,2 and AB are in parallel
11 //arm AB is a short circuit path
12
13 //calculations
14 //norton's equivalent circuit method

```

```

15 Isc=(v1/r1)+(v2/r2); //current through short circuit
    path in amperes
16 aRb=(r1*r2)/(r1+r2); //equivalent resistance in ohms
17 //now 6ohm resistor is placed in arm AB
18 aIb=Isc*((aRb)/(aRb+R)); //current through 6 ohm
    resistor in amperes
19
20 //output
21 mprintf('the constants for norton equivalent
    generator are %3.1f A and %3.1f ohm \n the
    current through the 6 ohm resistor is %3.1f A',
    Isc ,aRb ,aIb)

```

Scilab code Exa 1.6 finding current using nortons theorem

```

1 clc
2 clear
3
4 //input
5 v1=5; //voltage of battery in arm 1 in volts
6 v2=10; //voltage of battery in arm 2 in volts
7 v3=20; //voltage of battery in arm 3 in volts
8 r1=3; //internal resistance of battery in arm 1 in
    ohms
9 r2=8; //internal resistance of battery in arm 2 in
    ohms
10 r3=24; //internal resistance of battery in arm 3 in
    ohms
11 //arms 1,2,3 and AB are in parallel with each other
    and AB are in open condition
12 r4=6; //resistance between node formed by arms 1,2
    and 3 and point A in ohms
13 R0=7; //load resistance to be connected in arm AB in
    ohms
14 //calculations

```



```

15 //norton's equivalent method
16 //batteries are neglected. so, only internal
    resistances remain in the arms
17 R=1/((1/r1)+(1/r2)+(1/r3)); //equivalent resistance
    in ohms
18 aRb=R+r4; // total resistance when looked into the
    circuit from arm AB in ohm
19 //applying superposition principle to determine the
    short circuit current
20 //battery in arm 1 alone is considered
21 R1=r1+(1/((1/r2)+(1/r3)+(1/r4))); //effective
    resistance in ohms
22 I1=v1/R1; //current in amperes
23 pd=I1*r1; //potential drop across the parallel
    combination in volts
24 aIb1=pd/r4; //current in amperes
25 //battery in the arm 2 alone is considered
26 R2=r2+(1/((1/r1)+(1/r3)+(1/r4))); // effective
    resistance in ohms
27 I2=v2/R2; //current in amperes
28 V1=I2/((1/r1)+(1/r3)+(1/r4)); //voltage in volts
29 aIb2=V1/r4; //current in amperes
30 //battery in the arm 3 alone is considered
31 R3=r3+(1/((1/r1)+(1/r2)+(1/r4))); //effective
    resistance in ohms
32 I3=v3/R3; //current in amperes
33 V2=I3/((1/r1)+(1/r2)+(1/r4)); //voltage in volts
34 aIb3=V2/r4; //current in amperes
35 Isc=aIb1+aIb2+aIb3; //short circuit current in
    amperes
36 I=Isc*(aRb/(aRb+R0)); //current through load resistor
    in amperes
37
38 //output
39 mprintf('Nortons equivalent generator will produce a
    constant current of %3.3f A and has a shunt
    resistance of %3.0f ohms \n the current through
    the external resistor will be %3.1f A',Isc,r2,I)

```

Scilab code Exa 1.7 finding current using nortons theorem

```
1  clc
2  clear
3
4  //input
5  //AB,BC,CD,DA are arms of a wheatstone bridge
6  r1=4; //resistance in arm AB in ohms
7  r2=6; //resistance in arm BC in ohms
8  r3=5; //resistance in arm CD in ohms
9  r4=3; //resistance in arm DA in ohms
10 v=4; //d.c. supply given between points A and C in
    volt
11 R0=10; //resistance of the detector placed between
    the points B and D in ohms
12 //a detector is placed between the point B and D
13
14 //calculations
15 // noerton's equivalent circuit method
16 R1=((r1*r2)/(r1+r2))+((r3*r4)/(r3+r4)); // equivalent
    resistance assuming short circuit between poin A
    and C in ohms
17 R2=((r1*r4)/(r1+r4))+((r2*r3)/(r2+r3)); //equivalent
    resistance assuming short circuit between points
    B and D in ohms
18 I1=v/R2; // total current in amperes
19 aIb=v*(r4/(R2*(r4+r1))); //current in arm AB in
    amperes
20 aVDb=v*aIb; //voltage drop in arm AB
21 bVDc=v-aVDb; //voltage drop in arm DC
22 bIc=bVDc/r2; //current in arm BC in amperes
23 dIb=bIc-aIb; //current in arm DB in amperes
24 Isc=dIb; //short circuit current in amperes
25 I=Isc*(R1/(R1+R0)); //current through the detector in
```

```

        amperes
26
27 //output
28 mprintf('nortons equivalent generator produces %3.5
        f A and has a shunt resistance of %3.3f ohms \n
        the current through the detector will be %3.3f A'
        ,Isc,R1,I)

```

Scilab code Exa 1.8 delta to star conversion

```

1  clc
2  clear
3
4  //input
5  //arma AB,BC and CA forms delta connection
6  r1=2;//resistance in arm AB in ohms
7  r2=3;//resistance in arm BC in ohms
8  r3=5;//resistance in arm CA in ohms
9
10 //calculations
11 //conversion of given delta into star connection
12 //let N be the star point
13 R1=(r1*r2)/(r1+r2+r3);//resistance in arm AN in ohms
14 R2=(r2*r3)/(r1+r2+r3);//resistance in arm BN in ohms
15 R3=(r1*r3)/(r1+r2+r3);//resistance in arm CN in ohms
16
17 //output
18 mprintf('the respective star connected resistances
        are %3.1f ohm,%3.1f ohm and %3.1f ohm',R1,R2,R3 )

```

Scilab code Exa 1.9 finding the currents in wheatstone bridge using delta to star

```

1  clc

```

```

2  clear
3
4  //input
5  //AB,BC,CD,DA are arms of a wheatstone bridge
6  r1=5; //resistance in arm AB in ohms
7  r2=20; //resistance in arm BC in ohms
8  r3=15; //resistance in arm CD in ohms
9  r4=4; //resistance in arm DA in ohms
10 v=4; //d.c. supply given between points A and C in
    volt
11 r0=0.5; // internal resistances pf the d.c. supply in
    ohms
12 r5=15; //resistance in arm BD in ohms
13
14 //calculations
15 //BCD is replaced by equivalent star connection
16 //assume N as star piont after conversion
17 bRn=(r2*r3)/(r3+r2+r5); //resistance in arm BN in
    ohms
18 cRn=(r2*r5)/(r3+r2+r5); //resistance in arm CN in
    ohms
19 dRn=(r5*r3)/(r3+r2+r5); //resistance in arm DN in
    ohms
20 R=r0+cRn+(((r1+bRn)*(r4+dRn))/(r1+bRn+r4+dRn)); //
    total resistance in ohms after conversion
21 I=v/R; //totalcurrent supply in amperes
22 I1=(v/R)*((r4+dRn)/(r1+bRn+r4+dRn)); //current
    between points A and B in amperes
23 I2=I-I1; //current between points A and D in amperes
24 V1=I1*r1; //voltage drop across r1 in volts
25 V2=I2*r4; //voltage drop across r4 in volts
26 V3=V2-V1; //voltage drop across r5 in volts and B is
    positive to D
27 I3=V3/r5; //current between points B and D in amperes
28 I4=I1-I3; //current between points B and C in amperes
29 I5=I2+I3; //current between points D and C in amperes
30
31 //output

```

```

32 mprintf('the currents in each part of the circuit
    are \n It= %3.3f A \n aIb= %3.3f A \n aId= %3.3f
    A \n bId= %3.3f A \n bIc= %3.3f A \n dIc= %3.3f A
    ',I,I1,I2,I3,I4,I5)

```

Scilab code Exa 1.10 star to delta conversion and finding conductances

```

1 clc
2 clear
3
4 //input
5 //AN,BN,CN are connected in star fashion where N is
   the nuetral point
6 r1=5;//resistance in arm AN in ohms
7 r2=20;//resistance in arm BN in ohms
8 r3=10;//resistance in arm CN in ohms
9
10 //calculations
11 //star to delta conversion
12 Y1=1/r1;//conductance of arm AN in seimens
13 Y2=1/r2;//conductance of arm BN in seimens
14 Y3=1/r3;//conductance of arm CN in seimens
15 R1=1/((Y1*Y2)/(Y1+Y2+Y3));//resistance of arm AB in
   ohms
16 R2=1/((Y2*Y3)/(Y1+Y2+Y3));//resistance of arm BC in
   ohms
17 R3=1/((Y1*Y3)/(Y1+Y2+Y3));//resistance of arm CA in
   ohms
18
19 //ouput
20 mprintf('the equivalent resistances values for delta
    circuit are %3.0f ohms, %3.0f ohms and %3.1f
    ohms ',R1,R2,R3)

```

Scilab code Exa 1.11 finding current using star to delta transform

```
1  clc
2  clear
3
4  //input
5  //AB,BC,CD,DA forms an unbalanced wheatstone's
   bridge
6  r1=2; //resistance in arm AB in ohms
7  r2=5; //resistance in arm BC in ohms
8  r3=6; //resistance in arm CD in ohms
9  r4=2; //resistance in arm DA in ohms
10 r5=10; //resistance of detector placed between the
    points B and D
11 v=4; //battery supplying d.c. voltage in volts which
    is placed between points A and C
12 r0=0.2; // internal resistance of the battery in ohms
13
14 //calculations
15 //AB,BC and BD are considered to be in star
    connection with B as star point
16 Y1=1/r1; //conductance of r1 in seimens
17 Y2=1/r2; //conductance of r2 in seimens
18 Y3=1/r5; //conductance of r5 in seimens
19 //after delta conversion
20 R1=1/((Y1*Y2)/(Y1+Y2+Y3)); //resistance between
    points A and B in ohms
21 R2=1/((Y2*Y3)/(Y1+Y2+Y3)); //resistance between
    points C and D in ohms
22 R3=1/((Y1*Y3)/(Y1+Y2+Y3)); //resistance between
    points D and A in ohms
23 Rad=(r4*R3)/(r4+R3); //effective resistance of arm AD
    in ohms
24 Rdc=(r3*R2)/(r3+R2); //effective resistance of arm DC
```

```

        in ohms
25 Radc=(Rad+Rdc); //effective resistance if arms AD and
    DC in ohms
26 R=r0+((R1*Radc)/(R1+Radc)); // total resistance of
    hte circuit in ohms
27 I=v/R; //total current in the circuit in amperes
28 I1=I*(R1/(R1+Radc)); //current in arm AD in amperes
29 I2=I-I1; //current in arm AB in amperes
30 V1=I1*r4; //voltage across arm AD in volts
31 V2=I2*r1; //voltage across arm AB in volts
32 V3=V1-V2; //voltage across arm BD in volts and B is
    positive to D
33 I3=V3/r5; //current in arm BD in amperes
34
35 //output
36 mprintf('the current in the detector is %3.3f A',I3)

```

Scilab code Exa 1.12 determining the maximum power transfered

```

1 clc
2 clear
3
4 //input
5 // a battery consists of 10 cells connected in series
6 v=1.5; //e.m.f. of each cell in volts
7 r=0.2; // internal resistance of each cell in ohms
8 n=10; //number of cells in the battery
9
10 //calculations
11 //for maximum power load resistance=internal
    resistance
12 R=n*r; //total internal resistance of hte battery in
    ohms
13 Rl=R; //load resistance in ohms
14 e=n*v; //total e.m.f. of battery in volts

```

```
15 I=e/(R+Rl); //current from battery in amperes
16 P=(I^2)*R; //heating loss in the battery in watts
17 V=e-(I*R); //terminal voltage in volts
18
19 //output
20 fprintf('The maximum value of power which the
    battery may transfer is %3.1f W and an equal
    quantity of power is dissipated in the battery. \
    n under these conditions the terminal p.d. is %3
    .1f V',P,V)
```

Chapter 2

fields

Scilab code Exa 2.1 finding energy stored in magnetic field

```
1  clc
2  clear
3  //input
4  r=5; //resistance of the coil in ohms
5  v=100; // d.c supply voltage to the coil in volts
6  l=100*(10^-3); // inductance of the coil in henry
7
8  //calculations
9  i=v/r; // value of the current in amperes
10 e=(1*(i^2))/2; // energy stored in the circuit in
    joules
11
12 //output
13 mprintf('the value of current is %3.2f amperes \n
    the energy stored in the magnetic field is %3.2f
    joules ',i,e)
```

Scilab code Exa 2.2 finding energy stored in magnetic field

```

1  clc
2  clear
3
4  //input
5  l=0.5; //length of an air cored cylinder in meters
6  d1=0.05; // diameter of an air cored cylinder in
    meters
7  n=400; //number of turns of copper wire wound around
    the cylinder
8  d2=0.001; //diameter of the copper wire wound in
    meters
9  v=14; //dc supply voltage in volts
10 r=1.71*(10^-8); // resistivity of copper in ohm
    meteres
11 u0=1.257*(10^-6); // permeabilty of free space
12 ur=1; //relative permeability
13
14 //calculations
15 L=(u0*ur*(n^2)*(%pi*(d1^2)))/(4*l); //inductance of
    the coil in henry
16 R=(r*n*(d1+d2)*%pi*4)/(%pi*(d2^2)); // resistance of
    the field in ohm
17 i=v/R; //current in the field in amperes
18 e=(L*(i^2))/2; // energy stored in the field in
    joules
19
20 //output
21 mprintf('the inductanec of the coil is %3.10f H \n
    the resistance of the field is %3.10f ohm \n the
    energy stored in the field is %3.10f J',L,R,e)

```

Scilab code Exa 2.3 finding energy stored

```

1  clc
2  clear

```

```

3
4 //input
5 mmf=1800; // magneto motive force in amperes
6 l1=0.8; // length of iron in meters
7 l2=0.002; //length of air gap in meters
8 a=9*(10^-4); // area of the air gap in square meters
9 ui=2000; // relative permeability of iron
10 ua=1; // relative permeability of air
11 u0=1.257*(10^-6); // absolute permeability of free
    space
12
13 //calculations
14 b=(mmf*u0)/((l1/ui)+(l2/ua)); // flux density in
    tesla
15 e=(b^2)/(2*u0*ui); //energy stored in joules/cubic
    meter
16 v=l1*a; // volume of the iron in cubic meters
17 E=v*e; // total energy stored in the iron in joules
18
19 // output
20 mprintf('flux density is %3.10f T \n energy stored
    is %3.10f J/cubic m \n volume of the iron is %3
    .10f cubic m \n total energy stored in the iron
    is %3.10f J',b,e,v,E)

```

Scilab code Exa 2.4 estimation of coupling factor

```

1 clc
2 clear
3
4 //input
5 l1=0.4; //inductance of the first coil in henry
    which is in series with the second
6 l2=0.1; //inductance of the second coil in henry
7 i=5; // current through both the coils in amperes

```

```

8 e=2.25; // energy stored in magnetic field in joules
9
10 //calculations
11 L=(2*e)/(i^2); //total inductance in henry
12 M=(l1+l2-L)/2; // mutual inductance between the
    coils in henry
13 K=M/((l1*l2)^(0.5)); // coupling factor between the
    coils
14
15 //output
16 mprintf('total inductance is %3.10f H \n mutual
    inductance between the coils is %3.10f H \n the
    coupling factor is %3.10f',L,M,K)

```

Scilab code Exa 2.5 finding the load that can be lifted by a magnet

```

1 clc
2 clear
3
4 //input
5 l1=0.5; //length of iron bar in meters which is bent
    into horse shoe lifting magnet
6 a=1*(10^-3); // cross sectional area in cubic meters
7 n=500; // number of turns wound
8 i=4; //current flowing in amperes
9 ui=1100; // relative permeability of iron
10 ua=1; //relative permeability of air gap
11 l2=0.001; //length of the air gap
12 k=1.1; //leakage coefficient
13 u0=1.257*(10^-6); //absolute permeability
14
15 //calculations
16 b=(n*i*u0)/(((k*l1)/ui)+((2*a)/ua)); //flux density
    in tesla
17 P=((b^2)*2*l2)/(2*u0*ua); //increase in stored

```

```

        energy due to movement of the load by magnet in
        joules
18 m=P/9.81; //mass lifted in kilo grams
19
20 //output
21 mprintf('fulx density is %3.10f T \n increase in
        stored energy is %3.2f J \n mass that can be
        lifted by the magnet is %3.2f Kg',b,P,m)

```

Scilab code Exa 2.6 finding area of hysteresis loop and power loss

```

1  clc
2  clear
3
4  //input
5  h=500; //hysteresis losses of the rotor of a d.c.
        machine in joule/cubic meter/cycle
6  n=50; //number of cycles of magnetisation
7  d=0.0075; //density of the material in mg/cubic
        meter
8  H=10; //magnetising force in ampere/meter per mm
        when hysteresis loop is plotted on a graph
9  B=0.02; //flux density in tesla per mm when
        hysteresis loop is plotted on a graph
10
11 //calculations
12 e=B*H; //energy represented by 1square mm in joules
13 a=h/e; //area of loop in square mm
14 p=h*n; //power loss in watts per cubic meter
15 P=(p*(10^-6))/d; //power loss in watts per Kg
16
17 //output
18 mprintf('the area of hysteresis loop is %3.10f sq.mm
        \n the power loss is %3.10f W/Kg',a,P)

```

Scilab code Exa 2.7 finding the speed of a machine

```
1  clc
2  clear
3
4  //input
5  p=6; //number of poles of a d.c. machine
6  v=0.01; // volume of iron in cubic meters
7  d=0.0079; //density of the iron in mg/square meter
8  hi=4; // hysteresis loss of iron in W/Kg
9  hl=619; //loss given by hysteresis loop in joule/
    cubic meter/cycle
10
11 //calculations
12 h=hi*d*v*(10^6); // total hysteresis losses in watts
13 f=h/(hl*v); // frequency in cycles/second
14 n=(f*60)/3; //rotor undergoes 3 cycles of
    magnetisation in each revolution and speed in rev
    /minute
15 a=(f*2*%pi)/3; // angular velocity if rotor in
    radian per second
16
17 //output
18 mprintf('the speed of the machine will be %3.10f rev
    /min or %3.10f rad/s',n,a)
```

Scilab code Exa 2.8 finding maximum permissible volume of transformer core

```
1  clc
2  clear
3
4  //input
```

```

5 a=2500; //area of hysteresis loop in square
  millimeter
6 H=16; //magnetising force in ampere/meter per mm when
  hysteresis loop is plotted on a graph
7 B=0.02; //flux density in tesla per mm when
  hysteresis loop is plotted on a graph
8 hloss=24; //desired hysteresis loss
9 n=50; //cycles of magnetisation
10
11 //calculations
12 e=B*H; //energy represented by square millimeter
13 l=a*e; //loss/cubic meter/cycle
14 Vmax=hloss/(l*n); //maximum volume core in cubic
  meter
15
16 //output
17 mprintf('the permissible volume of the transformer
  core is %3.10f cubicmeter',Vmax)

```

Scilab code Exa 2.9 comparing energies stored in different fields

```

1 clc
2 clear
3
4 //input
5 l=0.002; //length in meters
6 a=0.01; //area in square meters
7 pd=250000; //potential gradient in V/m
8 h=250000; //magnetic force in A/m
9 e0=8.85*(10^-12); //absolute permittivity
10 er=1; //relative permittivity of air
11 u0=1.257*(10^-6); //absolute permeability
12 ur=1; //relative permeability of air
13
14 //calculations

```

```

15 D=e0*er*pd;//electric flux density in C/sq.m
16 Ee=((D^2)*l*a)/(2*e0*er);//energy stored in electric
    field in joules
17 B=h*u0*ur;//magnetic flux density
18 Em=((B^2)*l*a)/(2*u0*ur);//energy stored in magnetic
    field
19 k=Ee/Em;//ratio of energy in electric field to
    magnetic field
20
21 //output
22 fprintf('the ratio of energies in electric to
    magnetic field is %3.10f :1 ',k)

```

Scilab code Exa 2.10 finding energy stored in capacitor

```

1  clc
2  clear
3
4  //input
5  c1=2*(10^-6);// capacitance of first capacitor in
    farad which is connected in series with second
6  c2=6*(10^-6);// capacitance of second capacitor in
    farad which is connected in series with first
7  v=240;//d.c. voltage supply in volts
8
9  //calculations
10 ct=(c1*c2)/(c1+c2);//effective capacitance in farad
11 q=ct*v;//total charge in coulombs
12 e1=(q^2)/(2*c1);// energy stored in first capacitor
    in joules
13 e2=(q^2)/(2*c2);// energy stored in second capacitor
    in joules
14
15 //output
16 fprintf('the energy stored in first capacitor is %3

```



```
.10f J \n the energy stored in second capacitor  
is %3.10f J',e1,e2)
```

Scilab code Exa 2.11 finding potential difference and different energies

```
1  clc  
2  clear  
3  
4  //input  
5  c1=0.000005; //capacitance of first capacitor in  
    farad  
6  c2=0.000003; //capacitance of second capacitor in  
    farad  
7  v=200; //potential difference to which capacitor is  
    charged in volts  
8  
9  //calculations  
10 q1=c1*v; // charge given to first capacitor  
11 ct=c1+c2; // total capacitance in farad  
12 pd=q1/ct; // final potential difference across  
    combination in volts  
13 Eo=(c1*v*v)/2; //original energy in system in joules  
14 Ef=(pd*pd*(c1+c2))/2; //final energy in system in  
    joules  
15  
16 //output  
17 mprintf('the initial energy stored in the capacitor  
    is %3.10f J and final energy stored in the  
    combination is %3.10f J',Eo,Ef)
```

Scilab code Exa 2.12 finding equivalent resistance

```
1  clc
```

```

2 clear
3
4 //input
5 c=0.000002; // capacitance of a capacitor in farad
6 theta=0.12; // loss angle in radians
7 v=230; // a.c. voltage supply in volts
8 f=50; //supply frequency in hertz
9
10 //calculations
11 ic=v*2*%pi*f*c; // capacitor current in amperes
12 ir=ic*tan(theta); // current through shunt resistance
    in amperes
13 r=v/ir; // shunt resistance in ohm
14
15 //output
16 mprintf('the value of the equivalent shunt
    resistance is %3.10f ohm',r)

```

Scilab code Exa 2.13 finding energy dissipated in a material

```

1 clc
2 clear
3
4 //input
5 s=1; //side of square piece of wood which is clamped
    between two mettalic plates in meters
6 t=0.005; //thickness of square piece of wood which is
    clamped between two mettalic plates in meters
7 pd=20; //applied potential difference in volts
8 f=25000000; //supply frequency in hertz
9 er=4; //relative permittivity of the wood
10 theta=0.2 // loss angle in radians
11 T=10; //time in minutes
12 e0=8.85*(10^-12); //absolute permittivity
13

```

```
14 //calculations
15 P=(pd*pd*2*%pi*f*e0*er*s*s*theta)/t;// power loss in
    watts
16 E=P*60*T;// energy dissipated in ten minutes in
    joules
17
18 //output
19 mprintf('the energy dissipated in the wood in 10 min
    is %3.10f J',E)
```

Chapter 3

d c machines

Scilab code Exa 3.1 determination of angular speed

```
1  clc
2  clear
3
4  //input
5  n1=420; //number of conductors in armature of a d.c.
      machine
6  phi=0.024; //flux produced by each pole in weber
7  e=250; //desired e.m.f in volts
8  n2=4; //number of poles of the d.c. machine
9
10 //calculations
11 N=n1/2; //number of conductors per path and there are
      two parallel paths
12 //e1= e.m.f induced per conductor=(4*0.024*w)/(2*%pi
      ) where w is the required angular velocity in rad
      /s
13 w=e/((n1*(48*10^-3))/(2*%pi)); //required angular
      velocity in rad/s
14
15 //output
16 printf('the armature of hte machine must have an
```

angular velocity of %3.0f rad/s',w)

Scilab code Exa 3.2 finding output of a machine in different cases

```
1  clc
2  clear
3
4  //input
5  n1=200; //number of armature conductors
6  i=5; //current capability of each conductor in
    amperes
7  n2=4; //number of poles in the machine
8  e=1; //e.m.f. induced in each pole in volts
9
10 //calculations
11 //for a wave winding
12 n3=2; //number of parallel paths
13 n4=n1/n3; //number of conductors per path
14 e1=e*n4; //e.m.f of the machine in volts
15 i1=n3*i; //current capacity in amperes
16 op1=i1*e1; //output of the machine in watts
17 //for a lap winding
18 n5=n2; //number of parallel paths=number of poles
19 n6=n1/n5; //number of conductors per path
20 e2=n6*e; //e.m.f. of the machine in volts
21 i2=n5*i; //current capacity in amperes
22 op2=i2*e2; //output of the machine in volts
23
24 //output
25 mprintf('the output of the machine if armature is
    wave wound is %3.3f W and lap wound is %3.3f W',
    op1, op2)
```

Scilab code Exa 3.3 finding induced emf

```
1  clc
2  clear
3
4  //input
5  n1=480; //number of conductors in the armature
6  n2=6; //number of poles in the machine
7  w=100; //angular velocity in rad/s
8  phi=0.03; // flux per pole in weber
9
10 //calculations
11 phi1=n2*phi; //flux cut by each conductor in weber
12 e1=(phi1*w)/(2*%pi); //e.m.f. induced/conductor in
    volts
13 n3=n2; //number of parallel paths
14 n4=n1/n3; //number of conductors per path
15 e2=e1*n4; //e.m.f. per path in volts
16
17 //output
18 mprintf('the e.m.f. induced in the armature is %3.0f
    V', e2)
```

Scilab code Exa 3.4 determination of torque produced

```
1  clc
2  clear
3
4  //input
5  n1=16; //number of coils under the influence of the
    poles at any instant
6  phi=0.03; //flux produced by each coil in weber
7  a1=(200*300*(10^-6)); //area of a pole in square
    meter
8  n2=8; //number of turns in each coil
```

```

9 d=0.25; //diameter of the armature in meters
10 i=12; // current in the armature conductors in
    amperes
11 l=0.3; //length of the pole in meters
12
13 //calculations
14 b=phi/a1; //flux density under poles in tesla
15 f1=b*i*l; //force acting on 1 conductor in newton
16 f2=n2*f1; //force per coil side in newton
17 t1=f2*(d/2); //toque per coil side in newton meter
18 t2=t1*2; //total torque per coil in newton meter
19 T=n1*t2; //total torque on armature in newton meter
20
21 //output
22 mprintf('the total exerted on the armature is %3.1f
    Nm',T)

```

Scilab code Exa 3.5 finding power output of the motor

```

1 clc
2 clear
3
4 //input
5 d=0.25; //diameter of a pulley placed on the end of
    hte shaft of a d.c. motor in meter
6 m=60; //mass attached by a rope to the pulley in kg
7 w=50; //angular velocity of the pulley in rad/sec
8
9 //calculations
10 f=m*9.81; //force acting on the pulley in newton
    meter
11 W=f*%pi*d; //work done in one revolution
12 v=(d/2)*w;
13 p=(f*v)/1000; //power in kilo watts
14

```

```
15 //output
16 mprintf('the output of the motor is %3.2f kW',p)
```

Scilab code Exa 3.6 finding required torque

```
1 clc
2 clear
3
4 //input
5 e=235; //e.m.f generated by an armature of a d.c.
   machine in volts
6 v=100; //velocity of armature of a d.c. machine in
   rad/s
7 i=16; //current in amperes
8
9 //calculations
10 p=e*i; //power of armature in watts
11 t=p/v; //required torque in newton meter
12
13 //output
14 mprintf('required torque is %3.1f Nm',t)
```

Scilab code Exa 3.7 finding required flux per pole

```
1 clc
2 clear
3
4 //input
5 n1=4; //number of poles in a d.c. machine
6 n2=290; //number of conductors in the armature which
   are connected in lap winding
7 i=20; //armature current in amperes
8 t=50; //torque produced in newton meter
```



```

9
10 //calculations
11 phi=((t*(2*%pi))/(n2*i))*1000;//required flux per
    pole in milliweber
12
13 //output
14 mprintf('the required flux per pole is %3.1f mWb',
    phi)

```

Scilab code Exa 3.8 finding terminal voltage of a shunt generator

```

1 clc
2 clear
3
4 //input
5 ra=0.05;//armature resistance of a d.c. shunt
    generator in ohms
6 rf=120;//feild resistance of a d.c. shunt generator
    in ohms
7 li=98;//load current in amperes
8 lv=240;//load voltage in volts
9 ia2=60;//reduced current in armature in amperes
10
11 //calculations
12 //generated e.m.f. remains constant
13 if=lv/rf;//feild current in amperes
14 ia1=li+if;//armature current in amperes
15 e=lv+(ia1*ra);//generated e.m.f. in volts
16 V=e-(ia2*ra);//final terminal voltage in amperes
17
18 //output
19 mprintf('for an armature of 60A the terminal p.d.
    will be %3.0f',V)

```

Scilab code Exa 3.9 finding power developed in the armature

```
1  clc
2  clear
3
4  //input
5  ra=0.1; //armature resistance of a shunt generator in
      ohms
6  rf=250; //feild resistance of a shunt generator in
      ohms
7  p=7250; //load supplied by the shunt generator in
      watts
8  v=250; //voltage of shunt generator in volts
9
10 //calculations
11 il=p/v; //load current in amperes
12 if=v/rf; //feild current in amperes
13 ia=il+if; //armature current in amperes
14 e=v+(ia*ra); //generated e.m.f. in volts
15 P=(e*ia)/1000; //armature power in kW
16
17 //output
18 mprintf('the power developed in the armature will be
      %3.2 f kW',P)
```

Scilab code Exa 3.10 finding different efficiencies

```
1  clc
2  clear
3
4  //input
5  v=230; //voltage of a shunt generator in volts
```

```

6 ra=0.2; //armature resistance of the shunt generator
  in ohms
7 rf=115; //feild resistance of the shunt generator in
  ohms
8 n=0.85; //overall effeciency in per units
9 il=37; //load current in amperes
10
11 //calculations
12 inp=(v*il)/n; //input in watts
13 inp1=inp/1000; //input power in kilo watts
14 fi=v/rf; //feild current in amperes
15 ai=il+fi; //armature current in amperes
16 e=v+(ai*ra); //generated e.m.f. in volts
17 ap=e*ai; //armature power in watts
18 ml=inp-ap; //mechanical losses in watts
19 nm=ap/inp; //mechanical effeciency in per units
20 Nm=nm*100;
21 ne=(v*il)/ap; //electrical effeciency in per units
22 Ne=ne*100;
23
24 //output
25 mprintf('the input power will be %3.0f kW and the
  mechanical losses are %3.0f W \n the mechanical
  and electrical effeciencies are %3.1f per cent and
  %3.1f per cent ',inp1,ml,Nm,Ne)

```

Scilab code Exa 3.11 finding output of series generator

```

1 clc
2 clear
3
4 //input
5 ra=0.08; //armature resistance of a d.c. series
  generator in ohms
6 rf=0.1; //feild resistance of a d.c. series generator

```

```

        in ohms
7  il=50; //load current in amperes
8  e=250; //e.m.f. generated in volts
9
10 //calculations
11 R=ra+rf; //total resistance of machine in ohms
12 pd=e-(il*R); //terminal p.d. in volts
13 p=pd*il; //power output in watts
14 P=p/1000; //power output in kilo watts
15
16 //output
17 mprintf('the power output of the generator is %3.2f
        kW',P)

```

Scilab code Exa 3.12 finding different efficiencies of a series generator

```

1  clc
2  clear
3
4  //input
5  v=240; //voltage of d.c. series generator in volts
6  ra=0.1; //armature resistance of d.c. series
        generator in ohms
7  rf=0.15; //field resistance of d.c. series generator
        in ohms
8  n=0.87; //overall efficiency in per units
9  lp=7200; //load power in watts
10
11 //calculations
12 il=lp/v; //load current in amperes
13 R=ra+rf; //total resistance in ohms
14 e=v+(il*R); //generated e.m.f. in volts
15 ap=e*il; //armature power in watts
16 ne=(lp/ap); //electrical efficiency in per units
17 ne1=ne*100;

```

```

18 nm=(n/ne)*100; //mechanical effeciency
19
20 //output
21 mprintf('the electrical and mechanical effeciencies
        are %3.0f per cent and %3.1f per cent',ne1,nm)

```

Scilab code Exa 3.13 finding velocity of shunt motor

```

1  clc
2  clear
3
4  //input
5  v=250; //voltage of shunt motor in volts
6  ra=0.2; //armature resistance of shunt motor in ohms
7  rf=250; //feild resistance of shunt motor in ohms
8  w=75; //velocity of shunt motor in rad/sec
9  i1=21; //current taken by the motor in amperes
10 i2=60; //changed current in amperes
11
12 //calculations
13 fi=v/rf; //feild current in amperes
14 ai=i1-fi; //armature current in amperes
15 e1=v-(ai*ra); //induced e.m.f. in volts
16 e2=v-(i2*ra); //induced e.m.f. for changed current in
        volts
17 W=w*(e2/e1); //new speed in rad/sec
18
19 //ouput
20 mprintf('with an armature current of 60A the motor
        speed will be %3.1f rad/s ',W)

```

Scilab code Exa 3.14 finding total torque produced

```

1  clc
2  clear
3
4  //input
5  v=240; //voltage of a d.c. shunt motor in volts
6  ra=0.4; //armature resistance of d.c. shunt motor in
      ohms
7  rf=120; //armature resistance of d.c. shunt motor in
      ohms
8  is=22; //supply current in amperes
9  w=600; //angular velocity of motor in rev/min
10 il=30; //load current in amperes
11
12 //calculations
13 //armature reaction is neglected
14 W=(w*(2*pi))/60; //angular velocity in rad/s
15 fi=v/rf; //feild current in amperes
16 ai=is-fi; //armature current in amperes
17 e=v-(ai*ra); //e.m.f. in volts
18 t1=(e*ai)/W; //torque when current is 20A in newton
      meter
19 aI=il-fi; //changed armature current in amperes
20 t2=t1*(aI/is); //torque when current is 30A in newton
      meter
21
22 //output
23 mprintf('with a supply current of 30A the motor
      produces a total torque of %3.1f Nm',t2)

```

Scilab code Exa 3.15 finding overall efficiency of motor

```

1  clc
2  clear
3
4  //input

```

```

5 v=250; //voltage of a d.c. shunt motor in volts
6 ra=0.4; //armature resistance of a d.c. shunt motor
  in ohms
7 rf=250; //field resistance of a d.c. shunt motor in
  ohms
8 t=80; //total torque in newton meter
9 w=75; //velocity in rad/s
10 ml=0.1; //mechanical losses in per units
11
12 //calculations
13 ap=t*w; //armature power in watts
14 //(ia^2)-625ia+15000=0 will be the equation obtained
  from the e.m.f. equation
15 //(-ia+25)(ia-600)=0 is simplified equation
16 ai=25; //armature current in amperes as 600A armature
  current is inadmissable
17 fi=v/rf; //field current in amperes
18 inpI=ai+fi; //input current in amperes
19 inpP=v*inpI; //power input in watts
20 outP=0.9*t*w; //output power in watts and 0.9 is used
  after considering the 10% mechanical losses
21 n=outP/inpP; //overall effeciency in p.u.
22
23 //output
24 mprintf('for the loading condition the overall
  efficiency is %3.3f p.u.',n )

```

Scilab code Exa 3.16 finding speed of armature of dc series motor

```

1 clc
2 clear
3
4 //input
5 v=240; //voltage of a d.c. series motor in volts
6 rm=0.2; //resistance of the motor in ohms

```

```

7 w=80; // velocity of motor in rad/s
8 i1=20; //current in amperes
9 i2=30; //changed current in the armature in amperes
10
11 //calculations
12 //it is assumed that flux/pole is proportional to
    the field current
13 e1=v-(i1*rm); //e.m.f. induced in volts when the
    current is 20 A
14 e2=v-(i2*rm); //e.m.f. induced in volts when the
    current is 30 A
15 W=(e2/e1)*(i1/i2)*w; //final velocity in rad/s
16
17 //output
18 mprintf('with the increased current the motor will
    run with a velocity of %3.2f rad/s',W)

```

Scilab code Exa 3.17 finding required current

```

1 clc
2 clear
3
4 //input
5 //for a series motor
6 i1=40; //current in amperes
7 t1=110; //torque in newton meter
8 t2=75; //torque in newton meter
9
10 //calculations
11 //it assumed that up to a current of 50A the
    magnetizing curve for the motor is linear
12 i2=((t2/t1)*(i1^2))^0.5; //required torque in newton
    meter
13
14 //ouput

```



```
15 mprintf('the current to produce a total torque of 75
    Nm is %3.0f A',i2)
```

Scilab code Exa 3.18 finding total and shaft torque

```
1 clc
2 clear
3
4 //input
5 n1=4; //number of poles in a aeries motor
6 v=240; //voltage of the series motor in volts
7 n2=348; //number of conductors in the armature which
    is wave connected
8 r=0.8; //resistance in ohms
9 i=45; //current taken by the motor in amperes
10 phi=0.028; //flux/pole in weber
11 outP=8200; //output power in watts
12
13 //calculations
14 t=(phi*n2*2*i)/(2*pi); //since wave winding 2 is
    taken and the torque in newton meter
15 e=v-(i*r); //e.m.f. induced in volts
16 ap=e*i; //armature power in watts
17 w=(ap/t); //angular velocity in rad/s
18 st=outP/w; //shaft torque in newton meter
19
20 //output
21 mprintf('the total torque and the shaft torque
    produced by the motor are %3.0f Nm and %3.0f Nm',
    t,st)
```

Scilab code Exa 3.19 finding speed of the motor

```

1  clc
2  clear
3
4  //input
5  v1=240; //voltage of a d.c. shunt motor in volts
6  ra=1; //armature current in ohms of a d.c. shunt
    motor
7  rf=240; //field current in ohms of a d.c. shunt motor
8  ifl=20; //full load current in amperes
9  w=200; //speed in rad/s
10 v2=200; //reduced voltage in volts
11
12 //calculations
13 //flux/pole is assumed to be proportional to the
    field current
14 //for a 240V supply
15 E1=v1-(ifl*ra); //induced e.m.f. in volts
16 i=ifl*(v1/v2); //new current in amperes
17 E2=v2-(i*ra); //induced e.m.f. for new current in
    volts
18 W=w*(E2/E1)*(i/ifl); //new speed in rad/s
19
20 //output
21 mprintf('with the reduced voltage the motor will run
    at %3.0f rad/s',W)

```

Scilab code Exa 3.20 finding speed of the motor

```

1  clc
2  clear
3
4  //input
5  rm=0.5; //resistance of a series motor in ohms
6  w=100; //velocity in rad/sec
7  i=25; //current taken by the motor in amperes

```

```

8 v=250; //supply voltage in volts
9 r=2.5; //resistance connected in series with armature
    in ohms
10
11 //calculations
12 //armature current remains constant
13 E1=v-(i*rm); //e.m.f. induced under normal conditions
14 R=r+rm; //total resistance of circuit in ohms
15 E2=v-(i*R); //new induced e.m.f. in volts
16 W=(E2/E1)*w; //new speed for the same current in rad/
    s
17
18 //output
19 mprintf('with resistor in series with the armature
    the motor will run at %3.1f rad/s',W)

```

Scilab code Exa 3.21 finding value of regulator resistance

```

1 clc
2 clear
3
4 //input
5 v=240; //voltage of a shunt motor in volts
6 ra=0.4; //armature resistance in ohms of the shunt
    motor
7 rf=160; //field resistance in ohms of the shunt motor
8 ia=30; //armature current in amperes
9 w=1250; //speed in rev/min
10
11 //calculations
12 //it is assumed that flux is proportoinal to the
    field current
13 E1=v-(ia*ra); //induced e.m.f. in volts
14 fi=v/rf; //field current in amperes
15 k=E1/(fi*w);

```

```

16 //if=k*(v/r2) where r2 is the resistance to be added
17 //ia1=(3*r2)/16 and E2=v-(ra*ia1)
18 //(E2/E1)=((24-0.4ia1)/228) and (E2/E1)=(192/r2)
19 //we get an equation for r2 as (r2^2)-(3200*r2)
    +583680=0
20 r21=((3200+(((3200*3200)-(4*1*583680))^0.5))/2);//
    one of two solution for r2 in ohms
21 r22=((3200-(((3200*3200)-(4*1*583680))^0.5))/2);//
    one of two solution for r2 in ohms
22 R=r22-rf;//final resistance to be added in ohms and
    r22 is considered as the other value is too large
    and impractical
23
24 //ouput
25 mprintf('resistance to be added is %3.0f ohms',R)

```

Scilab code Exa 3.22 calculation of speed of motor

```

1 clc
2 clear
3
4 //input
5 v=250;//voltage of the series motor in volts
6 ra=0.25;//armature resistance of the series motor in
    ohms
7 rf=0.2;//field resistance of the series motor in
    ohms
8 i=60;//current taken by the motor in amperes
9 w=90;//speed of the motor in rad/s
10 r0=0.4;//resistance added in parallel with the field
    in ohms
11
12 //calculations
13 //it is assumed that flux is propertoinal to the
    field current and load is constant

```

```
14 E1=v-(i*(rf+ra));//motor e.m.f. in volts
15 I=i/((r0/(r0+rf))^0.5);//current in amperes
16 E2=v-(I*ra)-((I*rf)*(r0/(r0+rf)));//new motor e.m.f.
    in volts
17 W=(E2/E1)*(i/I)*((r0+rf)/r0)*w;//increased speed of
    the motor in rad/s
18
19 //output
20 mprintf('with resistor connected the speed of the
    motor will increase to %3.0f rad/s',W)
```

Chapter 4

the single phase a c series circuit

Scilab code Exa 4.1 finding the current taken by the coil

```
1  clc
2  clear
3
4  //input
5  r=10; //resistance of a coil in ohms
6  l=0.08; //inductance of the coil in henry
7  v=250; //a.c. supply voltage in volts
8  f=50; //supply frequency in hertz
9
10 //calculations
11 Xl=2*pi*f*l; //reactance of the coil in ohms
12 z=((r^2)+(Xl^2))^0.5; //impedance of the circuit
13 I=v/z; //current in amperes
14 phi=acos(r/z); // phase angle in radians
15 PHI=(phi*180)/%pi; //phase angle in degrees
16
17 //output
18 mprintf('the coil will take a current of %3.2f A
          lagging by %3.0f degree on the voltage ',I,PHI)
```

Scilab code Exa 4.2 finding the phase angle and magnitude of current

```
1  clc
2  clear
3
4  //input
5  r=12; //resistance connected in series with a coil in
      ohms
6  rc=4; //resistance of the coil in ohms
7  l=0.02; //inductance of the coil in henry
8  v=230; //a.c. supply voltage in volts
9  f=50; //frequency of the supply in hertz
10
11 //calculations
12 R=r+rc; //total resistance of circuit in ohms
13 xl=2*pi*f*l; //reactance of the coil in ohms
14 z=((R^2)+(xl^2))^0.5; //impedance of the circuit in
      ohms
15 i=v/z; //current in amperes
16 phi=(acos(r/z))*(180/(2*pi)); //angle of phase
      difference in degrees
17 vr=i*r; //voltage drop across resistor in volts
18 vc=i*(((rc^2)+(xl^2))^0.5); //voltage drop across
      coil in volts
19
20 //output
21 mprintf('the current taken from the supply is %3.1f
      A lagging by %3.1f degree.\n the voltage drops
      across the resistor and the coil are %3.0f V and
      %3.0f V', i, phi, vr, vc)
```

Scilab code Exa 4.3 finding required components of a coil

```

1  clc
2  clear
3
4  //input
5  r1=10;//resistance of first coil in ohms
6  l1=0.05;//inductance of first coil in henry
7  v1=150;//limit of voltage drop across of first coil
   in volts
8  v=240;//supply a.c. voltage in volts
9  f=50;//frequency of supply in hertz
10 a=40;//angle by which current lags the combined
    circuit after adding another coil to the first
    coil in series in degrees
11
12 //calculations
13 R=2*%pi*f*l1;//reactance of first coil in ohms
14 z=((r1^2)+(R^2))^0.5;//impedance of the first coil
    in ohms
15 i=v1/z;//maximum safe current in amperes
16 Z=v/i;//total impedance in ohms
17 Rt=Z*cos(a*(%pi/180));//total resistance in ohms
18 r2=Rt-r1;//resistance of the second coil in ohms
19 xt=Z*sin(a*(%pi/180));//total reactance in ohms
20 x2=xt-R;//reactance of the second coil in ohms
21 l2=x2/(2*%pi*f);//inductance of the second coil in
    henry
22 L=l2*1000;//inductance of the second coil in
    millihenry
23
24 //output
25 mprintf('the second coil must have a resistance of
    %3.1f ohm and an inductance of %3.1f mH',r2,L)

```

Scilab code Exa 4.4 finding the resistance and inductance of a coil


```

1  clc
2  clear
3
4  //input
5  //given voltage and current equations are v=354*(
    sin(314*t)) volts , i=14.1*(sin((314*t)-0.5))
    amperes
6  vmax=354; //maximum voltage in volts
7  imax=14.1; //maximum current in amperes
8  phi=0.5; //phase angle in radians
9  f=50; //supply frequency in hertz
10
11 //calculations
12 V=0.707*vmax; //voltmeter reading placed in the
    circuit
13 I=0.707*imax; //ammeter reading placed in circuit
14 z=V/I; //impedance of the coil in ohms
15 R=z*cos(phi); //resistance in ohms
16 xl=z*sin(phi); //reactance of coil in ohms
17 l=(xl/(2*pi*f))*1000; //inductance of the coil in
    millihenry
18
19 //output
20 mprintf('the coil has a resistance of %3.0f ohm and
    an inductance of %3.0f mH \n the instrument
    readings will be %3.0f V and %3.0f A',R,l,V,I)

```

Scilab code Exa 4.5 calculation of required capacitance

```

1  clc
2  clear
3
4  //input
5  i=0.5; //current taken by filament of an electric
    lamp in amperes

```

```

6 v1=110; //supply voltage in volts
7 v2=240; //changed supply in volts
8 f=50; //supply frequency in hertz
9
10 //calculations
11 z=v2/i; //impedance in ohms
12 r=v1/i; //resistance of the lamp
13 xc=((z^2)-(r^2))^0.5; //reactance of the capacitor
    added to the lamp in series in ohms
14 c=(10^6)/(2*pi*f*xc); //capacitance in microfarad
15 //this can also be solved using phasor diagram
16
17 //output
18 mprintf('the required value of the capacitance is %3
    .1f microfarad ',c)

```

Scilab code Exa 4.6 determination of current and voltage

```

1 clc
2 clear
3
4 //input
5 r=10; //resistance of an inductor in ohms
6 l=0.08; //inductance in henry
7 c=200*(10^-6); //capacitance of the capacitor
    connected in series to the inductor in farad
8 v=240; //supply voltage in volts
9 f=50; //supply frequency in hertz
10
11 //calculations
12 xl=2*pi*f*l; //reactance of the inductor in ohms
13 xc=1/(2*pi*f*c); //reactance of the capacitor in
    ohms
14 R=xl-xc; //total reactance of the circuit in ohms
15 z=((r^2)+(R^2))^0.5; //impedance of the circuit in

```

```

    ohms
16 I=v/z;//current in ohms
17 phi=(180/%pi)*acos(r/z);//phase angle in degrees
18 pd=I*(((r^2)+(xl^2))^0.5);//p.d. across inductor in
    volts
19
20 //output
21 mprintf('the current taken from the supply is %3.1f
    A lagging on the voltage by %3.1f degrees and the
    voltage drop across the inductor is %3.0f V',I,
    phi,pd)

```

Scilab code Exa 4.7 determination of voltage equation

```

1 clc
2 clear
3
4 //input
5 r0=15;//resistance added in series with an inductor
    and capacitor in ohms
6 r1=5;//resistance of the inductor in ohms
7 l=0.03;//inductance of the inductor in henry
8 c=250*(10^-6);//capacitance in farad
9 //i=14.5sin(314t) is the given current expression
10 w=314;//from the current expression
11 im=14.5;//from the current expression
12
13 //calculations
14 xl=w*l;//reactance of coil in ohms
15 xc=1/(w*c);//reactance of capacitor in ohms
16 r=r0+r1;//total resistance in ohms
17 R=xc-xl;//total reactance in ohms
18 z=((r^2)+(R^2))^0.5;//impedance in ohms
19 vm=im*z;//maximum voltage in volts
20 phi=acos(r/z);//phase angle in radians

```

```

21
22 //output
23 mprintf('the supply voltage will be V= %3.0f sin((%3
    .0f t)- %3.3f)',vm,w,phi)

```

Scilab code Exa 4.8 finding frequency and potential differences

```

1  clc
2  clear
3
4  //input
5  r=12; //resistance of the coil in ohms
6  l=0.08; //inductance of the coil in henry
7  c=150*(10^-6); //capacitance of capacitor connected
    in series in farad
8  v=240; //supply voltage in volts
9  i=20; //desired current in amperes
10
11 //calculations
12 z=v/i; //impedance in ohms
13 w=((1/(l*c))^0.5); //angular frequency in rad/sec
14 f=w/(2*pi); //frequency required in hertz
15 xl=w*l; //inductive reactance in ohms
16 pdc=xl*i; //p.d. across the capacitor in volts
17 pd=i*(((r^2)+(xl^2))^0.5); //p.d. across the coil
18
19 //ouput
20 mprintf('the frequency at which the current will be
    20A is %3.0f Hz and at this frequency the p.d.s
    across the coil and across the capacitor will be
    %3.0f V and %3.0f V respectively ',f,pd,pdc)

```

Scilab code Exa 4.9 calculation of required capacitance

```

1  clc
2  clear
3
4  //input
5  f=100000; //frequency in hertz
6  r=5; //resistance of the coil in ohms
7  l=0.0016; //inductance of the coil in henry
8
9  //calculations
10 x1=2*%pi*f*l; //inductive reactance of the coil in
    ohms
11 c=(10^12)/(2*%pi*f*x1); //capacitance required for
    resonance in pico farad
12
13 //output
14 mprintf('the series capacitor must be turned to %3.0
    f pF to produce resonance at 100kHz',c)

```

Scilab code Exa 4.10 calculations of required frequency and currents

```

1  clc
2  clear
3
4  //input
5  r=1; //resistance of the coil in ohms
6  l1=10*(10^-6); //inductance of coil in henry
7  c1=1*(10^-6); //capacitor which is connected in
    series with the coil in farad
8  l2=20*(10^-6); //changed inductance in henry
9  c2=0.5*(10^-6); //changed capacitance in farad
10 v=10; //supply volts in volts
11
12 //calculations
13 f0=1/(2*%pi*((l1*c1)^0.5)); //resonant frequency in
    hertz

```

```

14 F0=0.9*f0; //required resonant frequency in hertz
15 x11=2*%pi*F0*l1; //inductive reactance in ohms
16 xc1=1/(2*%pi*F0*c1); //capacitive reactance in ohms
17 X=xc1-x11; //effective reactance in ohms
18 z=((r^2)+(X^2))^0.5; //impedance in ohms
19 i=v/z; //current in ohms
20 x12=2*%pi*f0*l2; //new inductive reactance in ohms
21 xc2=x12; // at resonance
22 x13=0.9*x12; //inductive reactacne at lower frequency
    in ohms
23 xc3=xc2/0.9; //inductive capacitance at lower
    frequency in ohms
24 X1=xc3-x13; //effective reatance in ohms
25 I=v/X1; //current in amperes
26
27 //output
28 mprintf('the value of the current at 0.9*resonant
    frequency is %3.2f A and at lower frequency with
    change in values of inductance and capacitance is
    %3.0f A',i,I)

```

Scilab code Exa 4.11 calculation of ratio between the pd and supply voltage

```

1  clc
2  clear
3
4  //input
5  c=200*(10^-12); //capacitance of a capacitor which is
    connected in series with a coil in farad
6  q=80; //Q factor
7  v=0.250; //supply voltage in volts
8  f=500000; //supply frequecy in hertz
9
10 //calculations
11 pd=q*v; //p.d. across the capacitor in volts

```

```

12 ic=pd*2*%pi*f*c;//capacitor current in amperes
13 r=v/ic;//resistance of the coil in ohms
14 xl=q*r;//reactance of coil in ohms
15 l=(xl/(2*%pi*f))*(10^6);//inductance of the coil in
    ohms
16
17 //output
18 mprintf('the resistance and the inductance of the
    coil are %3.1f ohms and %3.0f microH respectively
    ',r,l)

```

Scilab code Exa 4.12 determination of inductance and phase angle of the coil

```

1 clc
2 clear
3
4 //input
5 q=100;//Q factor of a coil
6 r=25;//resistance of the coil in ohms
7 //a capacitor is connected in series with the coil
8 f=400000;//resonant frequency in hertz
9 i=0.125;//current at resonance in amperes
10
11 //calculations
12 p=i*i*r;//power dissipated in coil in watts
13 e=p/f;//energy dissipated per cycle in joules
14 im=(2*i)^0.5;//assumed sinusoidal current in amperes
15 l=((q*p)/(2*%pi*f))*(2/(im^2))*1000;//inductance
    in millihenry
16 phi=acos(1/q);//phase angle in radians
17 c=(10^12)/(2*%pi*f*r*q);//capacitance in picofarad
18
19 //output
20 mprintf('the inductance and the phase angle of the
    coil are %3.1f mH and %3.2f radians and the

```

required capacitance for resonance is 3.0 pF ,
(ϕ, c)

Chapter 5

the single phase ac parallel circuit

Scilab code Exa 5.1 determining the current taken from the supply

```
1  clc
2  clear
3
4  //input
5  r=20; //pure resistance connected in parallel with a
      pure inductance in ohms
6  l=0.08; //pure inductance in henry
7  v=240; //supply voltage in volts
8  f=50; //supply frequency in hertz
9
10 //calculations
11 i1=v/r; //current in resistive branch in amperes
12 i2=v/(2*%pi*f*l); //current inductive branch in
      amperes
13 it=((i1*i1)+(i2*i2))^0.5; //total current in amperes
14 phi=(180/%pi)*acos(i1/it); //phase angle in degrees
15
16 //output
17 mprintf('the total current is %3.1f A lagging by %3
```

```
.1f degree',it,phi)
```

Scilab code Exa 5.2 finding current and phase angle

```
1  clc
2  clear
3
4  //input
5  r=25;//resistance of a non inductive resistor in
    ohms
6  rl=10;//resistance of the inductor
7  l=0.06;//inductance of the inductor in henry
8  //non inductive resistor and resistive inductor are
    connected in parallel
9  v=230;//supply voltage in volts
10 f=50;//supply frequency in hertz
11
12 //calculations
13 i1=v/r;//current in resistive branch in amperes
14 i2=v/(((rl*rl)+((2*pi*f*l)^2))^0.5);//current in
    reactive-resistive branch in amperes
15 phi=acos(rl/(2*pi*f*l));//phase angle in radians
16 it=i1+(i2*cos(phi));//total in-phase component in
    amperes
17 iq=i2*sin(phi);//total quadrature component in
    amperes
18 I=(((it*it)+(iq*iq))^0.5);//resultant current in
    amperes
19 phit=(180/pi)*acos(it/I);//phase angle in degrees
20
21 //output
22 mprintf('the total current is %3.1f A lagging by %3
    .0f degrees',I,phit)
```

Scilab code Exa 5.3 calculation of current taken from the supply

```
1  clc
2  clear
3
4  //input
5  //coils a and b in connected in parallel
6  v=240;//supply voltage in volts
7  f=50;//supply frequency in hertz
8  ra=10;//resistance of coil a in ohms
9  xla=25;//inductive reactance of coil a in ohms
10 rb=20;//resistance of coil b in ohms
11 xlb=12;//inductive reactance of coil b in ohms
12
13 //calculations
14 z1=((ra^2)+(xla^2))^0.5;//impedance of coil a in
    ohms
15 i1=v/z1;//current in coil a in amperes
16 cos1=ra/z1;//cosine of phase angle1
17 sin1=xla/z1;//sine of phase angle1
18 z2=((rb^2)+(xlb^2))^0.5;//impedance of coil b in
    ohms
19 i2=v/z2;//current in coil b in amperes
20 cos2=rb/z2;//cosine of phase angle2
21 sin2=xlb/z2;//sine of phase angle2
22 ii=(i1*cos1)+(i2*cos2);//total in phase component in
    amperes
23 iq=(i1*sin1)+(i2*sin2);//total quadrature component
    in amperes
24 I=((ii^2)+(iq^2))^0.5;//total current in amperes
25
26 //output
27 mprintf('the total current is %3.1f A',I)
```

Scilab code Exa 5.4 calculation of reactance and inductance

```
1  clc
2  clear
3
4  //input
5  i=10; //total current taken by two-branch parallel
      circuit in amperes
6  a=37*(%pi/180); //phase angle by which current lags
      by on the voltage in degrees
7  v=100; //voltage supply in volts
8  f=50; //frequency of supply in hertz
9  g1=0.03; //conductance of first branch in siemens
10 b1=0.04; //inductive susceptance of first branch in
      siemens
11
12 //calculations
13 gt=(i*cos(a))/v; //total conductance in siemens
14 bt=(i*sin(a))/v; //total susceptance in siemens
15 g2=gt-g1; //conductance of second branch in siemens
16 b2=bt-b1; //susceptance of second branch in siemens
17 y2=((g2^2)+(b2^2))^0.5; //admittance of second branch
18 r2=g2/(y2^2); //resistance of second branch in ohms
19 x2=b2/(y2^2); //reactance of second coil in ohms
20 l2=(1000*x2)/(2*%pi*f); //inductance of second coil
      in millihenry
21
22 //output
23 mprintf('the resistance and inductance of second
      branch are %3.2f ohm and %3.2f mH',r2,l2)
```

Scilab code Exa 5.5 determination of total current and phase angle in rc parallel

```

1  clc
2  clear
3
4  //input
5  r=30;//resistance of a resistance in ohms which is
    connected in parallel with a bank of capacitors
6  c=80*(10^-6);//capacitance of bank of capacitors in
    farad
7  v=240;//supply voltage in volts
8  f=50;//supply frequency in hertz
9
10 //calculations
11 i1=v/r;//current in phase with the voltage in
    amperes
12 i2=v*2*%pi*f*c;//current leading on voltage by 90
    degrees in amperes
13 i=((i1^2)+(i2^2))^0.5;//total current in amperes
14 phi=(180/%pi)*acos(i1/i);//phase angle in degrees
15
16 //output
17 mprintf('the total current is %3.0f A leading on the
    voltage by %3.0f degrees',i,phi)

```

Scilab code Exa 5.6 calculation of current using admittance method

```

1  clc
2  clear
3
4  //input
5  v=415;//supply voltage in volts
6  f=50;//supply frequency in hertz
7  r1=50;//resistance in branch 1 in ohms
8  r2=30;//resistance in branch 2 in ohms
9  c=50*(10^-6);//capacitance in branch 2 in farad
10 //branch 1 and 2 are in parallel

```

```

11
12 //calculations
13 g1=1/r1;//conductance of branch 1 in siemens
14 xc=1/(2*%pi*f*c);//reactance of branch 2 in siemens
15 z=((r2^2)+(xc^2))^0.5;//impedance in ohms
16 g2=r2/(z^2);//conductance of branch 2 in siemens
17 b2=xc/(z^2);//susceptance of branch 2 in siemens
18 gt=g1+g2;//total conductance in siemens
19 bt=0+b2;//total susceptance in siemens
20 yt=((gt^2)+(bt^2))^0.5;//total admittance in mho
21 it=v*yt;//total current in amperes
22 R=gt/(yt^2);//resistance of the series equivalent
    circuit in ohms
23 Xc=bt/(yt^2);//capacitive reactance of the series
    circuit in ohms
24
25 //output
26 mprintf('the current taken from the supply will be
    %3.1f A and the resistance and capacitive
    reactance of the equivalent series circuit are %3
    .0fohm and %3.0fohms respectively',it,R,Xc)

```

Scilab code Exa 5.7 finding current taken from the supply by an rlc parallel circuit

```

1 clc
2 clear
3
4 //input
5 r=32;//resistance in branch 1 in ohms
6 l=0.08;//inductance in branch 2 in henry
7 c=200*(10^-6);//capacitance in branch 3 in farad
8 //braches 1,2 and 3 are in parallel
9 v=240;//supply voltage in volts
10 f=50;//supply frequency in hertz
11

```

```

12 //calculations
13 g1=1/r;//conductance of branch 1 in siemens
14 b2=-1/(2*%pi*f*1);//susceptance of branch 2 in
    siemens
15 b3=2*%pi*f*c;//susceptance of branch 3 in siemens
16 bt=b2+b3;//total susceptance in siemens
17 yt=((g1^2)+(bt^2))^0.5;//total admittance in mho
18 it=v*yt;//total current in amperes
19 phi=(180/%pi)*acos(g1/yt);//phase angle in degrees
20
21 //output
22 mprintf('the total current will be %3.2f A leading
    on the voltage by %3.1f degrees ',it,phi)

```

Scilab code Exa 5.8 calculation of total current and phase angle

```

1  clc
2  clear
3
4  //input
5  r1=100;//resistance in branch 1 in ohms
6  r2=10;//resistance in branch 2 in ohms
7  l2=0.07;//inductance in branch 2 in henry
8  r3=10;//resistance in branch 3 in ohms
9  c3=100*(10^-6);//capacitance in branch 3 in farad
10 //branches 1,2 and 3 are in parallel with each other
11 v=250;//supply voltage in volts
12 f=50;//supply frequency in hertz
13
14 //calculations
15 it=v/r1;//total current in branch 1 in amperes
16 ii1=it;//since resistive branch
17 iq1=0;//since resistive branch
18 z2=((r2^2)+((2*%pi*f*l2)^2))^0.5;//impedance of
    branch 2 in ohms

```

```

19 i2=v/z2;//current in branch 2 in amperes
20 cos2=r2/z2;//cosine of phase angle
21 phi2=(180/%pi)*acos(cos2);//phase angle in degree
22 ii2=i2*cos2;//in phase component of branch2 in
    amperes
23 iq2=-i2*sin(acos(cos2));//quadrature component of
    branch 2 in amperes
24 z3=((r3^2)+((1/(2*pi*f*c3))^2))^0.5;//impedance of
    branch 3 in ohms
25 i3=v/z3;//current in branch 3 in amperes
26 cos3=r3/z3;//cosine of the phase angle
27 phi3=(180/%pi)*acos(cos3);//phase angle in degrees
28 ii3=i3*cos3;//in phase component of branch 3 in
    amperes
29 iq3=i3*sin(acos(cos2));//quadrature component of
    branch 3 in amperes
30 ii=ii1+ii2+ii3;//total in phase component in amperes
31 iq=iq1+iq2+iq3;//total quadrature component in
    amperes
32 it=((ii^2)+(iq^2))^0.5;//total current in amperes
33 cost=ii/it;//cosine of total phase angle
34 phit=(180/%pi)*acos(cost);//phase angle in degrees
35 zs=v/it;//equivalent series impedance in ohms
36 rs=zs*cost;//equivalent series resistance in ohms
37 xs=zs*sin(acos(cost));//equivalent series reactance
    in ohms
38 l=(xs*1000)/(2*pi*f);//inductance in millihenry
39
40 //output
41 mprintf('the total current is %3.2f A lagging by %3
    .0f degrees and the equivalent series circuit
    would be a resistive inductive circuit of %3.1f
    ohms and %3.0f mH',it,phit,rs,l )

```

Scilab code Exa 5.9 finding resonant frequency


```

1  clc
2  clear
3
4  //input
5  r=10; //resistance of an inductor in ohms
6  l=0.08; //inductance of an inductor in henry
7  c=150*(10^-6); //capacitance by which the inductor is
      shunted in farad
8  v=240; //supply voltage in volts
9
10 //calculation
11 z1=1/c; //impedance in henry
12 f0=(1/(2*pi))*(((z1-(r^2))/(l^2))^0.5); //resonant
      frequency in hertz
13 z=((r^2)+((2*pi*f0*l)^2))^0.5; //impedance in ohms
14 it=(v*r)/(z^2); //total current in amperes
15
16 //output
17 mprintf('the circuit will be in current resonance at
      a frequency of %3.1f Hz and at this frequency
      the supply current will be %3.1f A',f0,it)

```

Scilab code Exa 5.10 calculation of ratio between capacitor current and supply current

```

1  clc
2  clear
3
4  //input
5  r=2; //resistance of an inductor in ohms
6  l=0.07; //inductance of an inductor in henry which is
      in resonance with a capacitor
7  f=60; //resonant frequency in hertz
8
9  //calculations
10 tanphi=(2*pi*f*l)/r; //ratio between capacitor

```

```

        current and supply current
11
12 //output
13 mprintf('the ratio of capacitor current to supply
        current is %3.1f : 1',tanphi)

```

Scilab code Exa 5.11 calculation of resistance and inductance of load

```

1  clc
2  clear
3
4  //input
5  c=4*(10^-6); //capacitance of a capacitor by which a
        resistive-inductive load is shunted in farad
6  v=2; //supply voltage in volts
7  f=5000; //supply frequency in hertz
8  q=10; //Q factor of the circuit
9
10 //calculations
11 vwc=2*2*%pi*f*c; //capacitor current in amperes
12 it=vwc/q; //total current in amperes
13 i1=((vwc^2)+(it^2))^0.5; //load current in amperes
14 z1=v/i1; //load impedance in ohms
15 r1=z1*(it/i1); //resistance of load in ohms
16 x1=q*r1; //reactance of load in ohms
17 l=(x1*(10^6))/(2*%pi*f); //load inductance in
        microhenry
18
19 //output
20 mprintf('the load has a resistance of %3.3f ohms and
        an inductance of %3.0f microhenry',r1,l)

```

Chapter 6

operational methods

Scilab code Exa 6.1 calculation of current taken from the supply and its phase angle

```
1  clc
2  clear
3
4  //input
5  z=7.5+(%i*10); //impedance connected to a supply in
    ohms
6  r=7.5; //resistance from impedance in ohms
7  x=10; //reactance from impedance in ohms
8  v=200; //supply voltage in volts
9
10 //calculations
11 i=v/z; //current taken from supply in amperes
12 I=(((real(i))^2)+((imag(i))^2))^0.5; //current
    magnitude in amperes
13 phi=(180/%pi)*atan(-x/r); //phase angle in degrees
14 PHI=-phi; //lag
15
16 //output
17 mprintf('the supply current is %3.0f A lagging on
    the voltage by %3.0f',I,PHI)
```

Scilab code Exa 6.2 calculation of supply current and voltages and phase angle

```
1  clc
2  clear
3
4  //input
5  z1=5+(%i*5); //impedance 1 in ohms
6  z2=10-(%i*15); //impedance 2 in ohms
7  //impedances 1 and 2 are in series
8  v=240; //supply voltage in volts
9
10 //calculations
11 zt=z1+z2; //total impedance in ohms
12 i=v/zt; //current taken in amperes
13 v1=z1*i; //voltage 1 in volts
14 V1=(((real(v1))^2)+((imag(v1))^2))^0.5; //voltage
    magnitude in volts
15 phi1=(180/%pi)*atan((imag(v1))/(real(v1))); //phase
    angle 1 in degrees
16 v2=i*z2; //voltage 2 in volts
17 V2=(((real(v2))^2)+((imag(v2))^2))^0.5; //voltage
    magnitude in volts
18 phi2=(180/%pi)*atan(-(imag(v2))/(real(v2))); //phase
    angle 2 in degrees
19 I=(((real(i))^2)+((imag(i))^2))^0.5; //current
    magnitude in amperes
20
21 //output
22 mprintf('the supply current is%3.1f A and the two
    voltages are %3.0f V and %3.0f V leading by %3.1f
    degrees and lagging by %3.1f degrees
    respectively ',I,V1,V2,phi1,phi2)
```

Scilab code Exa 6.3 calculation of total impedance and the current

```
1  clc
2  clear
3
4  //input
5  z1=12+(%pi*16); //impedance 1 in ohms
6  z2=10-(%i*10); //impedance 2 in ohms
7  //impedances 1 and 2 are in parallel
8  v=240; //supply voltage in volts
9
10 //calculations
11 zt=(z1*z2)/(z1+z2); //total impedance in ohms
12 Z=((real(zt))^2+((imag(zt))^2))^0.5; //current
    magnitude in amperes
13 i=v/zt; //supply current in amperes
14 I=((real(i))^2+((imag(i))^2))^0.5; //current
    magnitude in amperes
15
16 //output
17 mprintf('the magnitude of total impedance is %3.1f
    ohms and of the supply current is %3.1f A',Z,I)
```

Scilab code Exa 6.4 calculation of current taken by a combination

```
1  clc
2  clear
3
4  //input
5  r1=10; //resistance of branch 1 in ohms
6  l1=0.08; //inductance of branch 1 in henry
7  r2=20; //resistance of branch 2 in ohms
```

```

8 c2=150*(10^-6); //capacitance of branch 2 in farad
9 //branch 1 and 2 are in parallel
10 v=240; //supply voltage in volts
11 f=50; //supply frequency in hertz
12
13 //calculations
14 x1=2*%pi*f*l1; //reactance of branch 1 in ohms
15 z1=r1+(%i*x1); //impedance of branch 1 in ohms
16 y1=1/z1; //admittance of branch 1 in mho
17 x2=1/(2*%pi*f*c2); //reactane of branch 2 in ohms
18 z2=r2-(%i*x2); //impedance of branch 2
19 y2=1/z2; //admittance of branch 2 in mho
20 yt=y1+y2; //total admittance in mho
21 it=v*yt; //supply current in amperes
22 I=((real(it))^2)+((imag(it))^2))^0.5; //current
    magnitude in amperes
23
24 //output
25 mprintf('the current taken from the supply is %3.2f
    A',I)

```

Scilab code Exa 6.5 calculation of current and phase angle

```

1 clc
2 clear
3
4 //input
5 r=20; //resistance of an inductor in ohms
6 x=15; //reactance of an inductor in ohms
7 v=250; //supply voltage in volts
8
9 //calculations
10 z=((r^2)+(x^2))^0.5; //magnitude of impedance in ohms
11 phi=(180/%pi)*atan(x/r); //phase angle in degrees
12 i=v/z; //current magnitude in amperes

```

```

13
14 //output
15 mprintf('the current will be %3.0f A lagging by %3.0
    f degrees ',i,phi)

```

Scilab code Exa 6.6 finding magnitude and phase angle of the voltage

```

1 clc
2 clear
3
4 //input
5 i=8-(%i*6); //current flowing in amperes
6 z=10+(%i*10); //impedance in ohms
7
8 //calculations
9 I=(((real(i))^2)+((imag(i))^2))^0.5; //current
    magnitude in amperes
10 Z=(((real(z))^2)+((imag(z))^2))^0.5; //magnitude of
    impedance in ohms
11 phi1=(180/%pi)*atan(-(imag(i))/(real(i))); //phase
    angle of current in degrees
12 phi2=(180/%pi)*atan(-(imag(z))/(real(z))); //phase
    angle of impedance in degrees
13 phi=-(phi2+phi1);
14 v=I*Z; //voltage across coil in volts
15
16 //output
17 mprintf('the voltage across the coil is %3.0f V
    leading by %3.0f degrees ',v,phi)

```

Scilab code Exa 6.7 calculating the components of equivalent series circuit

```

1 clc

```

```

2  clear
3
4  //input
5  z1=10+(%i*15); //first impedance in ohms
6  z2=15-(%i*25); //second impedance in ohms
7  //impedances 1 and 2 are connected in parallel
8
9  //calculations
10 Z1=(((real(z1)^2)+(imag(z1)^2)))^0.5; //magnitude of
    impedance 1 in ohms
11 Z2=(((real(z2)^2)+(imag(z2)^2)))^0.5; //magnitude of
    impedance 2 in ohms
12 phi1=(180/%pi)*atan((imag(z1))/real(z1)); //phase
    angle 1 in degrees
13 phi2=(180/%pi)*atan((imag(z2))/real(z2)); //phase
    angle 2 in degrees
14 Z=z1+z2; //total impedance in ohms
15 Zt=(((real(Z)^2)+(imag(Z)^2)))^0.5; //magnitude of
    total impedance in ohms
16 PHIt=(180/%pi)*atan((imag(Z))/real(Z)); //total phase
    angle in degrees
17 ZT=(Z1*Z2)/Zt; //magnitude of equivalent impedance in
    ohms
18 PHIT=phi1+phi2-PHIt; //phase angle of equivalent
    impedance in degrees
19 p=(PHIT*%pi)/180; // phase angle in radians
20 Zs=(ZT*cos(p))+(%i*(ZT*sin(p))); //series impedance
    in ohms
21 R=real(Zs); //resistance of equivalent series circuit
    in ohms
22 X=imag(Zs); //reactance of equivalent series circuit
    in ohms
23
24 //output
25 mprintf('the resistance and inductive reactance of
    equivalent series circuit are %3.1f ohm and %3.2f
    ohm',R,X)

```

Scilab code Exa 6.8 finding the magnitude and phase angle of current

```
1  clc
2  clear
3
4  //input
5  y1=0.01-(%i*0.03); //first admittance in mho
6  y2=0.05+(%i*0); //second admittance in mho
7  y3=%i*0.05; //third admittance in mho
8  //three admittances are connected in parallel
9  v=250; //supply voltage in volts
10
11 //calculations
12 y=y1+y2+y3; //total admittance in mho
13 Y=((real(y)^2)+(imag(y)^2))^0.5; //magnitude of
    total admittance in mho
14 phi=(180/%pi)*atan((imag(y))/(real(y))); //phase
    angle in degrees
15 i=v*Y; //current in amperes
16
17 //output
18 mprintf('the total current is %3.1f A leading on the
    voltage by %3.1f degrees',i,phi)
```

Chapter 7

power and power factor

Scilab code Exa 7.1 finding the average and instantaneous power

```
1  clc
2  clear
3
4  //input
5  r=20; //resistance of coil in ohms
6  l=0.04; //inductance of coil in henry
7  v=240; //supply voltage in volts
8  f=50; //frequency of supply in hertz
9
10 //calculations
11 x1=2*%pi*f*l; //reactance of coil in ohms
12 z=((r^2)+(x1^2))^0.5; //impedance of coil in ohms
13 i=v/z; //current in amperes
14 cosp=r/z; //cosine of phase angle
15 Pavg=v*i*cosp; //average power in watts
16 pmax=v*i*(cosp+1); //maximum instantaneous power in
    watts
17
18 //ouput
19 mprintf('the average power and the maximum
    instantaneous power in the coil are %3.0f W and
```

`%3.0f W respectively ',Pavg,pmax)`

Scilab code Exa 7.2 finding the time elapsed before maximum power

```
1  clc
2  clear
3
4  //input
5  //given e.m.f. equation is e=340sin(314t)V and
   current equation is i=12sin(314t-0.7)A
6  t=0.0015; //time in seconds after which the e.m.f. is
   zero and increasing positively
7  vm=340; //maximum voltage in volts from voltage
   equation
8  im=12; //maximum current in amperes from current
   equation
9  phi=0.7 //phase angle from current equation
10 w=314; //from voltage and current equations
11
12 //calculations
13 //when t=0.0015 seconds
14 p=vm*sin(w*t)*im*sin((w*t)-phi); //power in watts
15 pmax=(vm*im*((cos(phi))+1))/2; //maximum power in
   watts
16 T=(((acos(((2*pmax)/(vm*im))-cos(phi))))+phi)
   *(1000))/(2*w); //time interval in milliseconds
17
18 //output
19 mprintf('at a time of 1.5mS after the specified
   instant the power was %3.0f W and the maximum
   power occured %3.1f mS after the same specified
   instant ',p,T)
```

Scilab code Exa 7.3 calculation of apparent and reactive powers and the inductance

```
1  clc
2  clear
3
4  //input
5  z1=20; //impedance of the inductor in ohms
6  pf=0.45; //lagging power factor
7  v=240; //supply voltage in volts
8  f=50; //supply frequency in hertz
9
10 //calculations
11 i=v/z1; //current taken by the inductor in amperes
12 p=v*i*pf; //true power in the circuit in watts
13 pa=v*i; //apparent power in VA
14 pr=v*i*sin(acos(pf)); //reactive power in var
15 r=p/(i*i); //resistance in ohms
16 x1=((z1^2)-(r^2))^0.5; //reactance in ohms
17 l=(x1*1000)/(2*pi*f); //inductance in millihenry
18
19 //output
20 mprintf('the wattmeter will read %3.0f W \n the
    apparent and the reactive powers are %3.0f VA and
    %3.0f var respectively \n the inductance of the
    inductor is %3.0f mH',p,pa,pr,l)
```

Scilab code Exa 7.4 finding the total kVA loading and overall power factor

```
1  clc
2  clear
3
4  //input
5  d1=400; //load in kW at unity power factor
6  d2=1000; //load in kVA at a lagging power factor
7  d3=500; //load in kVA at a leading power factor
```

```

8 pf1=1;//unity power factor
9 pf2=0.71;//lagging power factor
10 pf3=0.8;//leading power factor
11
12 //calculations
13 pa=d1+(d2*pf2)+(d3*pf3);//total active power loading
    in watts
14 pr=(d2*pf2)-(d3*sin(acos(pf3)));//total reactive
    power in var
15 pk=(((pa^2)+(pr^2))^0.5)/1000;//total MVA loading
16 pf=pa/(pk*1000);//total power factor
17
18 //output
19 mprintf('the total load on the sub-station is %3.2f
    MVA at a lagging power factor of %3.3f ',pk,pf)

```

Scilab code Exa 7.5 finding total active power taken from the supply

```

1 clc
2 clear
3
4 //input
5 r1=10;//resistance of an inductor in ohms
6 l=0.05;//inductance of an inductor in henry
7 rc=20;//resistance in series with a capacitor in
    ohms
8 c=150*(10^-6);//capacitance of a capacitor in farad
9 //inductor is in parallel with the series circuit
    containing a resistor and a capacitor
10 v=240;//supply voltage in volts
11 f=50;//supply frequency in hertz
12
13 //calculations
14 x1=2*pi*f*l;//inductive reactance in ohms
15 z1=((r1^2)+(x1^2))^0.5;//impedance of the inductor

```

```

    in ohms
16 i1=v/z1;//current in inductor in amperes
17 phi1=r1/z1;//power factor of inductor
18 xc=1/(2*%pi*f*c);//capacitive reactance in ohms
19 z2=((rc^2)+(xc^2))^0.5;//impedance of series circuit
    in ohms
20 i2=v/z2;//current in series circuit in amperes
21 phi2=rc/z2;//power factor of series circuit
22 i=(i1*phi1)+(i2*phi2);//total in phase component in
    amperes
23 P=(v*i);//total power in watts
24
25 //output
26 mprintf('the active power taken from the supply is
    %3.0f W',P)

```

Scilab code Exa 7.6 calculation of total power and current taken form the supply u

```

1 clc
2 clear
3
4 //input
5 ra=5;//resistance of inductor in branch a in ohms
6 la=0.08;//inductance of the inductor in branch a in
    henry
7 rb=15;//resistance in branch 2 in ohms
8 cb=100*(10^-6);//capacitance in branch b in farad
9 v=240;//supply voltage in volts
10 f=50;//supply frequency in hertz
11
12 //calculations
13 //branches a and b are in parallel with supply
14 xa=2*%pi*f*la;//inductive reactance in ohms
15 za=((ra^2)+(xa^2))^0.5;//impedance in branch a in
    ohms

```

```

16 xc=1/(2*%pi*f*cb); //capacitive reactance in ohms
17 zb=((rb^2)+(xc^2))^0.5; //impedance in branch b in
    ohms
18 g=(ra/(za^2))+(rb/(zb^2)); //total conductance in
    siemens
19 b=(-xa/(za^2))+(xc/(zb^2)); //total susceptance in
    siemens
20 y=((g^2)+(b^2))^0.5; //total admittance in siemens
21 i=v*y; //total current in amperes
22 p=v*v*g; //total power taken from the supply in watts
23
24 //output
25 mprintf('the total current and power taken from the
    supply are %3.2f A and %3.0f W',i,p)

```

Scilab code Exa 7.7 finding required range of frequency

```

1  clc
2  clear
3
4  //input
5  r=10; //resistacne of an acceptor circuit in ohms
6  l=0.08; //inductance of an acceptor circuit in henry
7  c=1250*(10^-12); //capacitance of an acceptor circuit
    in faraf
8  v=1.5; //supply voltage in volts
9  //average power dissipated in not less tha half of
    power at resonance
10
11 //calcultions
12 i=v/r; //current in amperes
13 p=i*i*r; //power in watts
14 pmin=p*0.5; //minimum average power in watts
15 i1=pmin/r; //current in amperes
16 z1=v/i1; //impedans in ohms

```

```

17 x=((z1^2)-(r^2))^0.5;//effective reactance in ohms
18 //on equating xc and xl we get equation for
    frequency as  $-(502*(10^{-6}))(f^2)-10f+127.2(10^6)$ 
    =0
19 a= -502*(10^-6);//from the above equation
20 b= -10;//from the above equation
21 c=127.2*(10^6);//from the above equation
22 f2=((b-(((b^2)-(4*a*c))^0.5))/(2*a))/1000;//upper
    frequency in hertz
23 f1=(((-b)-(((b^2)-(4*a*c))^0.5))/(2*a))/1000;//
    lower frequency in hertz
24
25 //output
26 mprintf('the frequency range over which the average
    power doesnot fall below 0.5*the average power at
    resonance is %3.0f kHz and %3.0f kHz',f1,f2)

```

Scilab code Exa 7.8 calculation of required capacitance

```

1  clc
2  clear
3
4  //input
5  d=125;//power taken by an industrial load in
    kilowatts
6  pf=0.6;//power factor
7  v=415;//supply voltage in volts
8  f=50;//supply frequency in hertz
9
10 //calculations
11 phii=acos(pf);//initial phase angle in radians
12 kVAo=d/pf;//original kVA
13 kvaro=d*tan(phii);//original kvar
14 //for 0.9 power factor
15 phif=acos(0.9);//phase angle in radians

```



```

16 kvarf=d*tan(phif); //final kvar
17 kvarc=kvaro-kvarf; //capacitor kvar
18 c1=(kvarc*(10^3)*(10^6))/(v*v*2*%pi*f); //capacitance
    in microfarad
19 kVAf=d/0.9; //final kVA
20 kVAR=kVAo-kVAf; //reduction in kVA
21 //for unity power factor
22 kvarC=kvaro; //capacitor kvar
23 c2=(kvarC*(10^3)*(10^6))/(v*v*2*%pi*f); //capacitance
    in microfarad
24 kVAF=d; //final kVA
25 kVAR=kVAo-kVAF; //reduction in kVA
26
27 //output
28 mprintf('the required values of capacitance are %3.0
    f uF and %3.0f uF and the respective savings in
    kVA are %3.1f kVA and %3.1f kVA',c1,c2,kVAR,kVAR
    )

```

Scilab code Exa 7.9 calculation of required capacitance

```

1  clc
2  clear
3
4  //input
5  d=75; //load at lagging powerfactor in kW
6  pf=0.75; //lagging power factor
7  v=1100; //supply voltage in volts
8  f=50; //frequency in hertz
9  d0=10; //desired increment in load in kW
10
11 //calculations
12 kVAi=d/pf; //initial kVA
13 cos2=(d+d0)/kVAi; //final power factor
14 phi1=acos(pf);

```

```

15 phi2=acos(cos2);
16 kvarc=kVAi*(d0)*(sin(phi1)-sin(phi2)); //capacitor
    kvar
17 c=(kvarc*(10^3)*(10^6))/(v*v*2*pi*f); //capacitance
    required in microfarad
18
19 //output
20 mprintf('the power factor has to be increased to %3
    .2f lag and the value of capacitance required is
    %3.0f uF',cos2,c)

```

Scilab code Exa 7.10 calculation of pure resistive load for maximum power

```

1  clc
2  clear
3
4  //input
5  v=3.3; //voltage rating of an alternator in kV
6  ri=3; //internal resistance of alternator in ohms
7  xl=32; //series inductive reactance in ohms
8  rc=1; //resistance of a cable in ohms
9  xc=2; //effective reactance of the cable in ohms
10
11 //calculations
12 R=ri+rc; //resistance of line and alternator in ohms
13 X=xl+xc; //reactance of line and alternator in ohms
14 Z=((R^2)+(X^2))^0.5; //impedance of line and
    alternator in ohms
15 Rl=Z; //required load resistance in ohms
16 zt=(((Z+R)^2)+(X^2))^0.5; //total impedance of the
    circuit in ohms
17 I=(v*1000)/zt; //current in amperes
18 pmax=(I*I*Rl)/1000; //maximum power in load in
    kilowatts
19

```

```

20 //output
21 mprintf('to give a maximum load power of %3.0f kW the
        load must have a resistance of %3.2f ohms', pmax,
        Rl)

```

Scilab code Exa 7.11 calculation of components of a fully variable load

```

1  clc
2  clear
3
4  //input
5  r=10; //resistance in source impedance in kilohms
6  l=0.005; //inductance in source impedance in henry
7  v=100; //supply voltage in volts
8  f=10000; //supply frequency in hertz
9
10 //calculations
11 x1=2*pi*f*l; //inductive reactance in ohms
12 c=((10^6)*(10^3))/(2*pi*f*x1); //capacitance in
    picofarad
13
14 //output
15 mprintf('for maximum power transfer the load must
        consist of %3.0f kilo ohms resistance in series
        with a capacitance of %3.0f pF', r, c)

```

Scilab code Exa 7.12 calculation of power dissipated by the inductor

```

1  clc
2  clear
3
4  //input

```

```

5 r=20; //resistance of resistor connected in series
   with inductor in ohms
6 v=240; //supply voltage in volts
7 f=50; //supply frequency in hertz
8 pdr=130; //potential drop across resistor in volts
9 pdl=170; //potential drop across inductor in volts
10
11 //calculations
12 cosp=((v*v)-(pdr^2)-(pdl^2))/(2*pdr*pdl); //power
   factor
13 i=pdr/r; //current in amperes
14 p=pdl*i*cosp; //power in watts
15
16 //output
17 mprintf('the power dissipated by the inductor is %3
   .0f W',p)

```

Scilab code Exa 7.13 calculation of inductance resistance and the power loss

```

1 clc
2 clear
3
4 //input
5 r=32; //resistance connected in parallel with an
   inductor in ohms
6 v=240; //supply voltage in volts
7 f=50; //supply frequency in hertz
8 il=8; //current in inductor in amperes
9 it=14; //total current in amperes
10
11 //calculations
12 ir=v/r; //current in resistor in amperes
13 cosp=((it^2)-(ir^2)-(il^2))/(2*ir*il); //power factor
14 R=(v*cosp)/il; //resistance of inductor in ohms
15 xl=(v*sin(acos(cosp)))/il; //reactance in ohms

```

```

16 l=(x1*1000)/(2*%pi*f); //inductance in millihenry
17 p=i1*i1*R; //power loss in inductor in watts
18
19 //output
20 mprintf('the resistance and the inductance of the
           inductor are %3.2f ohms and %3.0f mH respectively
           and the power loss is %3.0f W',R,l,p)

```

Scilab code Exa 7.14 finding the power for the load and whole circuit

```

1  clc
2  clear
3
4  //input
5  i1=9; //current taken by a resistive inductive load
        form supply in amperes
6  v=250; //supply voltage in volts
7  f=50; //frequency in hertz
8  i2=12; //current taken when a resistor is placed in
        parallel with the load in amperes
9  r=50; //resistance of the resistor placed in parallel
10
11 //calculations
12 ir=v/r; //current through the resistor in amperes
13 cosp=((i2^2)-(ir^2)-(i1^2))/(2*i1*ir); //power factor
14 cosP=(ir+(i1*cosp))/i2; //power factor for whole
        circuit
15 pc=(v*i2*cosP)/1000; //power taken by whole circuit
        in kilowatts
16 pl=(v*i1*cosp); //power taken by load in watts
17
18 //output
19 mprintf('the values of power and power factor for
           the whole circuit and the load are %3.1f kW:%3.2f
           (lag) and %3.0f W:%3.2f (lag) respectively ',pc,

```

`cosP ,pl ,cosp)`

Chapter 8

three phase circuits

Scilab code Exa 8.1 finding the phase voltage and line current

```
1  clc
2  clear
3
4  //input
5  r=24; //resistance of each of three resistors
      connected in star in ohms
6  v=415; //3 phase supply in volts
7
8  //calculations
9  vp=v/(3^0.5); //phase voltage in volts
10 ip=vp/r; //phase current in amperes
11 il=ip; //for star connection
12
13 //output
14 mprintf('the phase voltage is %3.0f V and the
      current in each line is %3.0f A',vp,il)
```

Scilab code Exa 8.2 finding the line current and the phase angle

```

1  clc
2  clear
3
4  //input
5  r=15; //resistance of each of three coils connected
      in star in ohms
6  l=0.08; //inductance of each of three coils connected
      in star in in henry
7  v=415; //supply voltage in volts
8  f=50; //supply frequency in hertz
9
10 //calculations
11 zp=((r^2)+((2*pi*f*l)^2))^0.5; //impedance per phase
      in ohms
12 il=v/(zp*(3^0.5)); //line current in amperes
13 ip=il; //for star connection
14 phi=(180/pi)*acos(r/zp); //phase angle in degrees
15
16 //output
17 mprintf('the line current will be %3.1f A lagging on
      its corresponding phase voltage by %3.0f degrees
      ',il,phi)

```

Scilab code Exa 8.3 calculation of total line current and total phase angle

```

1  clc
2  clear
3
4  //input
5  v=415; //3 phase supply voltage in volts
6  f=50; //supply frequency in hertz
7  //system is loaded with three star connected coils
      and three star connected resistors
8  ic=10; //current taken by each of the coils in
      amperes lagging by 60 degrees

```



```

9 ir=8; //current taken by each of the resistors in
    amperes
10 phi=(60*%pi)/180; //lagging phase angle in radians
11
12 //calculations
13 ii=ir+(ic*cos(phi)); //sum of in phase components in
    amperes
14 iq=(ic*sin(phi)); //sum of quadrature components in
    amperes
15 i=((ii^2)+(iq^2))^0.5; //total current in amperes
16 PHI=(180/%pi)*acos(ii/i); //phase angle in degrees
17
18 //ouput
19 mprintf('the total line current is %3.1f A lagging
    on the relative phase voltage by %3.1f degrees',i
    ,PHI)

```

Scilab code Exa 8.4 illustration for neutral current is zero

```

1 clc
2 clear
3
4 //input
5 //three impedances of resistance and inductive
    reactance are connected in star
6 r=20; //resistance in ohms
7 x=15; //reactance in ohms
8 v=440; //three phase supply voltage in volts
9
10 //calculations
11 z=((r^2)+(x^2))^0.5; //each impedance in ohms
12 il=v/((3^0.5)*z); //line current in amperes
13 ip=il; //for star connections
14 cosp1=(180/%pi)*acos(r/z); //power factor1 in degrees
15 cosp2=120+cosp1; //each current is displaced by 120

```

```

degrees
16 cosp3=240+cosp1;//each current is displaced by 120
degrees
17 ii=il*((cos(acos(r/z))+cos((120+cosp1)*(%pi/180))+
cos((240+cosp1)*(%pi/180)));//total in phase
component in amperes
18 iq=il*-((sin(acos(r/z))+sin((120+cosp1)*(%pi/180))+
sin((240+cosp1)*(%pi/180)));//total quadrature
component in amperes
19
20 //output
21 mprintf('the the resultant in phase and quadrature
components are %3.5fA and %3.5fA respectively\
hence the sum of three balanced currents is zero
',ii,iq)

```

Scilab code Exa 8.5 calculation of phase and line currents

```

1 clc
2 clear
3
4 //input
5 //three resistors are connected in delta
6 r=30;//resistance of each resistor in ohms
7 v=240;//supply voltage in volts
8 f=50;//supply frequency in hertz
9
10 //calculations
11 ip=v/r;//phase current in amperes
12 il=ip*(3^0.5);//line current in amperes
13
14 //output
15 mprintf('the phase and line currents are %3.0f A and
%3.1f A respectively',ip,il)

```

Scilab code Exa 8.6 calculation of line current and phase angle

```
1 clc
2 clear
3
4 //input
5 //three impedances are connected in delta each
   containing a resistor and a capacitor
6 r=15; //resistance in ohms
7 c=100*(10^-6); //capacitance in farad
8 v=415; //3phase supply voltage in volts
9 f=50; //frequency in hertz
10
11 //calculations
12 xc=1/(2*%pi*f*c); //capacitive reactance in ohms
13 zp=((r^2)+(xc^2))^0.5; //impedance per phase in ohms
14 ip=v/zp; //phase current in amperes
15 il=ip*(3^0.5); //line current in amperes
16 phi=(180/%pi)*acos(r/zp); //leading phase angle in
   degrees
17
18 //output
19 mprintf('the line current is %3.1f A and the phase
   angle is %3.1f lead',il,phi)
```

Scilab code Exa 8.7 determination of line currents and phase angle in two cases

```
1 clc
2 clear
3
4 //input
```

```

5 //three impedances are connected in delta each
   containing a resistor and an inductor
6 r=25;//resistance in ohms
7 l=0.06;//inductance in henry
8 v=415;//3 phase supply voltage in volts
9 f=50;//supply frequency in hertz
10 //three capacitors are connected across the same
   supply in star
11 c=200*(10^-6);//the capacitance in farad
12
13 //calculations
14 //for delta connection
15 xl=2*%pi*f*l;//inductive reactance in ohms
16 zp=((r^2)+(xl^2))^0.5;//impedance per phase in ohms
17 ip=v/zp;//phase current in amperes
18 il=ip*(3^0.5);//line current in amperes
19 //il lags on ip by 30degrees.so the angle between
   the line current and ilne voltage is 30+phase
   angle in degrees
20 phi=30+((180/%pi)*acos(r/zp));//phase angle in
   degrees
21 cosp=(r/zp);//phase angle in radians
22 //for star connection
23 vp=v/(3^0.5);//phase voltage in volts
24 xc=1/(2*%pi*f*c);//capacitive reactance in ohms
25 ic=vp/xc;//current in amperes
26 //ic leads the line voltage by 60degrees
27 cosP=cos((60*%pi)/180);//phase angle in radians
28 ii=(il*cos((phi*%pi)/180))+(ic*(cosP));//in-phase
   components in amperes
29 iq=((-il*sin((phi*%pi)/180))+(ic*sin(acos(cosP))));
   //quadrature component in amperes
30 it=((ii^2)+(iq^2))^0.5;//total current in amperes
31 PHI=(180/%pi)*acos(ii/it);//phase angle in degrees
32
33 //output
34 mprintf('the original line current was %3.0f A
   lagging on the line voltage by %3.0f degrees and

```

the final current is %3.1f A lagging on the line
voltage by %3.1f degrees',il,phi,it,PHI)

Scilab code Exa 8.8 determination of line and motor phase currents

```
1  clc
2  clear
3
4  //input
5  p=50; //power rating of a delta connected 3 phase a.c
   . motor in kW
6  v=415; //voltage rating of a delta connected 3 phase
   a.c. motor in volts
7  n=0.85; //full load effeciency in per units
8  pf=0.87; //full load power factor
9
10 //calculations
11 inp=p/n; //full load input in kW
12 il=inp*(1000/((3^0.5)*v*pf)); //line current in
   amperes
13 ip=il/(3^0.5); //phase current in amperes
14
15 //output
16 mprintf('the line and motor phase currents are %3.0
   fA and %3.1fA respectively',il,ip)
```

Scilab code Exa 8.9 calculation of capacitance per phase

```
1  clc
2  clear
3
4  //input
```

```

5 p=27; //power rating of a delta connected 3 phase a.c
  . motor in kW
6 v=500; //voltage rating of a delta connected 3 phase
  a.c. motor in volts
7 n=0.9; //full load efficiency in per units
8 pf=0.7; //full load power factor
9 f=50; //general supply frequency in hertz
10
11 //calculations
12 il=(1000*p)/((3^0.5)*v*pf*n); //line current taken by
  motor in amperes
13 phi=acos(pf); //phase angle
14 //the line current will lag by phi radians on the
  line voltage
15 //to bring total current in phase with line voltage
  ic*sin60 must equal ilsin75.(information from
  phasor diagram)
16 ic=(il*sin(phi+0.524))/sin((60*%pi)/180); //capacitor
  current in amperes and 0.524 is 30degrees
  converted into radians and added in respect to
  above mentioned condition
17 c=(ic*1000000)/((3^0.5)*v*f*2*%pi); //capacitance per
  phase in micro farad
18
19 //output
20 mprintf('the required capacitance per phase is %3.0
  fuF ',c)

```

Scilab code Exa 8.10 determining the wattmeter readings for given conditions

```

1 clc
2 clear
3
4 //input
5 v=415; // three phase supply voltage in volts

```

```

6 f=50; //supply frequency in hertz
7 //the power taken from this supply is taken by a
   delta connected load with each branch consisting
   a resistor and an inductance is measured by two
   wattmeters
8 r=20; //resistance in ohms
9 l=0.06; //inductance in henry
10
11 //calculations
12 xp=2*%pi*f*l; //reactance per phase in ohms
13 zp=((r^2)+(xp^2))^0.5; //impedance per phase in ohms
14 ip=v/zp; //current per phase in amperes
15 il=ip*(3^0.5); //line current in amperes
16 phi=acos(r/zp); //phase angle in radians
17 phi1=(30*%pi)/180; //30 degrees converted into radians
18 w1=(v*il*cos(phi+phi1))/1000; //reading of wattmeter
   1 and 30 degrees is added with correspondence to
   phasor diagram in kilowatts
19 w2=(v*il*cos(phi-phi1))/1000; //reading of wattmeter
   2 and 30 degrees is added with correspondence to
   phasor diagram in kilowatts
20
21 mprintf('the readings on the two wattmeters will be
   %3.3 f kW and %3.2 f kW',w1,w2)

```

Chapter 9

the single phase transformer

Scilab code Exa 9.1 finding the number turns on secondary

```
1  clc
2  clear
3
4  //input
5  t1=96;//number turns on the primary side of an ideal
    transformer
6  v=240;//supply voltage in volts
7  f=50;//supply frequency in hertz
8  v2=660;//secondary pd in volts
9
10 //calculations
11 vp=v/t1;//primary volts per turn
12 vs=vp;//secondary volts per turn
13 t2=v2/vs;//secondary turns
14
15 //output
16 mprintf('to produce a p.d. of 660V the secondary
    coil should have %3.0f turns ',t2)
```

Scilab code Exa 9.2 finding the secondary turns and the full load primary and secondary currents

```
1  clc
2  clear
3
4  //input
5  vp=660; //primary voltage in volts
6  vs=1100; //secondary voltage in volts
7  f=50; //supply frequency in hertz
8  kva=10; //kVA rating of the transformer
9  t1=550; //number of primary turns
10
11 //calculations
12 pv=vp/t1; //primary volts per turn
13 t2=vs/pv; //number of secondary turns
14 inpi=(kva*1000)/vp; //input current in amperes
15 is=(kva*1000)/vs; //secondary current in amperes
16
17 //output
18 mprintf('the number of secondary turns is %3.0f and
           the respective primary and secondary currents are
           %3.1fA and %3.1fA ',t2,inpi,is)
```

Scilab code Exa 9.3 finding the mutual inductance between the windings

```
1  clc
2  clear
3
4  //input
5  t1=120; //primary turns of an ideal transformer
6  ls1=0.24; //self inductance of primary in henry
7  v=240; //supply voltage in volts
8  t2=300; //secondary turns of the ideal transformer
9
10 //calculations
```

```

11 d=v/ls1; //rate of change of current in A/s
12 v2=v*(t2/t1); //secondary voltage in volts
13 M=v2/d; //mutual impedance in henry
14 ls2=ls1*((t2*t2)/(t1*t1)); //self inductance of the
    secondary in henry
15
16 //output
17 mprintf('the mutual impedance between the coils is
    %3.1fH and the self inductance of the secondary
    winding is %3.1fH',M,ls2)

```

Scilab code Exa 9.4 finding magnetizing current and the no load loss

```

1  clc
2  clear
3
4  //input
5  i=0.4; //no load current in amperes
6  pf=0.25; //lagging power factor
7  v=250; //supply voltage in volts
8  f=50; //supply frequency in hertz
9
10 //calculations
11 ie=i*pf; //loss component of no load current in
    amperes
12 im=((i^2)-(ie^2))^0.5; //magnetizing component in
    amperes
13 p=v*ie; //no load power loss in watts
14
15 //output
16 mprintf('the magnetising current is %3.3fA and the
    no load loss is %3.0f W',im,p)

```

Scilab code Exa 9.5 finding the flux density in the core

```
1  clc
2  clear
3
4  //input
5  v=240; //supply voltage in volts
6  f=50; //supply frequency in hertz
7  t1=500; //number of primary turns
8  i0=0.35; //no load current in amperes
9  p=44; //power loss in watts
10 l=0.4; //magnetic length of the core in meters
11 ur=2000; //relative permeability of core
12 u0=1.257*(10^-6); //absolute permeability
13
14 //calculations
15 cosp=p/(v*i0); //no load power factor
16 im=i0*sin(acos(cosp)); //magnetizing current in
    amperes
17 b=(u0*ur*im*t1)/l; //flux density in tesla
18
19 //output
20 mprintf('the flux density produced in the core will
    be %3.3f T',b)
```

Scilab code Exa 9.6 determination of components of parallel circuit

```
1  clc
2  clear
3
4  //input
5  vp=440; //primary voltage in volts
6  vs=240; //secondary voltage in volts
7  f=50; //supply voltage in hertz
8  i0=0.5; //no load current in amperes
```

```

9 pf=0.3; //lagging power factor
10
11 //calculations
12 ii=i0*pf; //in phase component in amperes
13 r0=vp/(ii*1000); //resistance in ohms
14 iq=((i0^2)-(ii^2))^0.5; //quadrature component in
    amperes
15 x0=vp/iq; //reactance in ohms
16 l0=x0/(2*pi*f); //inductance in henry
17
18 //output
19 mprintf('the transformer on load may be represented
    by %3.2fkOhms resistance in parallel with a pure
    inductance of %3.2fH',r0,l0)

```

Scilab code Exa 9.7 finding number of primary and secondary turns

```

1 clc
2 clear
3
4 //input
5 vp=1100; //voltage on the primary in volts
6 vs=240; //secondary voltage in volts
7 f=50; //supply frequency in hertz
8 b=1.4; //flux density in tesla
9 s=0.2; //side of the square core in meter
10
11 //calculations
12 ag=s*s; //gross area of core in square meters
13 am=0.9*ag; //magnetic area of core in square meters
14 np=vp/(4.44*b*am*f); //number of turns in primary
15 ns=np*(vs/vp); //number of turns in secondary
16
17 //output
18 mprintf('the number of turns in the primary and

```

secondary winding would be %3.0f and %3.0f
respectively ',np,ns)

Scilab code Exa 9.8 estimation of flux density magnetizing current and core loss

```
1  clc
2  clear
3
4  //input
5  np=350;//number of turn in the primary
6  lm=0.8;//mean length of core in meters
7  am=0.006;//magnetic area in square meter
8  i0=0.8;//no load current in amperes
9  v=500;//supply voltage in volts
10 f=50;//frequency of supply in hertz
11 ur=2000;//relative permeability of the core
12 u0=1.257*(10^-6);//absolute permeability
13
14 //calculations
15 bm=v/(4.44*am*np*f);//maximum flux density in tesla
16 im=(bm*i0)/(u0*ur*np*(2^0.5));//magnetizing current
    in amperes
17 sinp=im/i0;//sine of no load phase angle
18 p=v*lm*cos(asin(im/i0));//power loss of core in
    watts
19
20 //output
21 mprintf('the maximum flux density in the core will
    be %3.3fT with a magnetizing current of %3.3fA
    and a core loss of %3.0fW',bm,im,p)
```

Scilab code Exa 9.9 calculation of different efficiencies and loading for maximum

```

1  clc
2  clear
3
4  //input
5  kva=20000; //kVA rating of the transformer in VA
6  vp=1100; //primary voltage in volts
7  vs=240; //secondary voltage in volts
8  pi=500; //iron losses in watts
9  pc=600; //full load copper losses in watts
10 pf=0.8; //lagging power factor
11
12 //calculations
13 out=kva*pf; //full load output in watts
14 fll=pi+pc; //full load losses in watts
15 n=out/(out+fll); //efficiency in perunits
16 hfl=kva/2; //unity power factor
17 cp=pc*(1/(2*2)); //copper loss in watts
18 n1=(hfl/1000)/((hfl/1000)+0.5+(cp/1000)); //
    efficiency in per units
19 kvat=(kva*((pi/pc)^0.5))/1000; // total kVA
20
21 //output
22 mprintf('the efficiencies on full load ,at 0.8 lag
    and 0.5*full load ,at unity power factor are %3.3f
    p.u. and %3.2f p.u. respectively.\n the loading
    for maximum efficiency is %3.2f kVA',n,n1,kvat)

```

Scilab code Exa 9.10 calculation of all day efficiency

```

1  clc
2  clear
3
4  //input
5  kva=10; //kVA rating of the transformer
6  vp=400; //voltage on primary side in volts

```

```

7 vs=230; //voltage on secondary side in volts
8 //short circuit test
9 ppd1=18; //primary p.d. in volts
10 ip1=25; //primary current in amperes
11 inp1=120; //power input in watts
12 //short circuit test
13 ppd2=400; //primary p.d. in volts
14 ip2=0.5; //primary current in amperes
15 inp2=70; //power input in watts
16
17 //calculations
18 zp=ppd1/ip1; //equivalent primary impedance in ohms
19 rp=inp1/(ip1^2); //equivalent resistance in ohms
20 xp=((zp^2)-(rp^2))^0.5; //equivalent leakage
    reactance in ohms
21 r0=(vp^2)/(1000*inp2); //resistance of parallel
    circuit
22 phi=sin(acos(inp2/(vp*ip2))); //sine of power factor
23 im=ip2*phi; //magnetizing current in amperes
24 x0=vp/im; //reactance in ohms
25
26 //output
27 mprintf('the equivalent circuit parameters are \n Rp
    =%3.3f ohms \n Xp=%3.3f ohms \n r0=%3.3f kilo
    ohms \n x0=%3.1f ohms ',rp, xp ,r0 ,x0)

```

Scilab code Exa 9.11 determination of equivalent circuit

```

1 clc
2 clear
3
4 //input
5 kva=10; //kVA rating of the transformer
6 vp=400; //voltage on primary side in volts
7 vs=230; //voltage on secondary side in volts

```

```

8 //short circuit test
9 ppd1=18;//primary p.d. in volts
10 ip1=25;//primary current in amperes
11 inp1=120;//power input in watts
12 //short circuit test
13 ppd2=400;//primary p.d. in volts
14 ip2=0.5;//primary current in amperes
15 inp2=70;//power input in watts
16
17 //calculations
18 zp=ppd1/ip1;//equivalent primary impedance in ohms
19 rp=inp1/(ip1^2);//equivalent resistance in ohms
20 xp=((zp^2)-(rp^2))^0.5;//equivalent leakage
    reactance in ohms
21 r0=(vp^2)/(1000*inp2);//resistance of parallel
    circuit
22 phi=sin(acos(inp2/(vp*ip2)));//sine of power factor
23 im=ip2*phi;//magnetizing current in amperes
24 x0=vp/im;//reactance in ohms
25
26 //output
27 mprintf('the equivalent circuit parameters are \n Rp
    =%3.3f ohms \n Xp=%3.3f ohms \n r0=%3.3f kilo
    ohms \n x0=%3.1f ohms ',rp, xp, r0, x0)

```

Scilab code Exa 9.12 finding the primary input current secondary terminal voltage

```

1 clc
2 clear
3
4 //input
5 kva=5;//kVA rating of the transformer
6 pf=0.8;//power factor
7 vp=250;//voltage on primary side in volts
8 vs=500;//voltage on secondary side in volts

```



```

 9 //from equivalent circuit
10 r0=750;//resistance in ohms
11 x0=325;//reactance in ohms
12 Rp=0.4;//equivalent resistance refered to primary
    side in ohms
13 Xp=0.75;//equivalent reactance refered to primary
    side in ohms
14
15 //calculations
16 is=(kva*1000)/vs;//full load secondary current in
    amperes
17 ip1=is*(vs/vp);//current in amperes
18 ep=vp-((ip1*pf)+(Xp*sin(acos(pf))));//in volts
19 Vs=ep*(vs/vp);// in volts
20 i1=vp/(vs+vp);//component of Io in phase with Vs in
    amperes
21 i2=i1*pf;//component of Ie in phase with Ip
22 i3=i1*sin(acos(pf));//component of Ie in quadrature
    with Ip
23 im=vp/x0;//magnetizing current in amperes
24 i4=im*sin(acos(pf));//component of Im in phase with
    Ip
25 i5=im*pf;//component of Im in quadrature with Ip
26 Ip=(((ip1+i2+i4)^2)+((i5-i3)^2))^0.5;//total primary
    current in amperes
27 P=vp*Ip*pf;//power input in watts
28 pc=ip1*ip1*i4;//copper loss in watts
29 pi=vp*i1;//iron loss in watts
30 n=1-((pc+pi)/P);//efficiency in per units
31
32 //output
33 mprintf('the primary input current is %3.2f A : the
    secondary terminal voltage is %3.0f V and the
    efficiency of the transformer is %3.2f p.u.',Ip,
    Vs,n)

```

Scilab code Exa 9.13 calculation of secondary terminal voltage

```
1  clc
2  clear
3
4  //input
5  //all values refered to primary and from given
   equivalent circuit
6  v=240; //supply voltage in volts
7  r0=0.25; //resistance in ohms
8  x0=0.4; //reactance in ohms
9  r1=7.75; //load resistance in ohms
10 x1=5.6; //load reactance in ohms
11 n=5; //turns ratio of the transformer
12
13 //calculations
14 rt=r0+r1; //total resistance of the circuit in ohms
15 xt=x0+x1; //total reactance of the circuit in ohms
16 zt=((rt^2)+(xt^2))^0.5; //total impedance of
   transformer and the load in ohms
17 Ip=v/zt; //current in amperes
18 z1=((r1^2)+(x1^2))^0.5; //impedance of load in ohms
19 d=Ip*z1; //voltage drop across referred load
   impedance in volts
20 vs=n*d; //secondary terminal voltage in volts
21
22 //output
23 mprintf('the secondary terminal voltage is %3.0f V',
   vs)
```

Chapter 10

synchronous and asynchronous machines

Scilab code Exa 10.1 determination of emf between ends of a coil

```
1  clc
2  clear
3
4  //input
5  p=4; //number of poles of an alternator
6  w=50*pi; //angular velocity in rad/sec
7  b=0.015; //sinusoidal flux per pole in weber
8  phi=10*(pi/180); //pole pitch in radians
9  kf=1.11; //form factor
10
11 //calculations
12 f=(w*(p/2))/(2*pi); //frequency in hertz
13 e=2*kf*b*f; //e.m.f. per conductor in volts
14 E=2*e*cos(phi/2); //total e.m.f. in volts
15
16 //ouput
17 mprintf('the e.m.f. between the ends of the coil is
           %3.1f V',E)
```

Scilab code Exa 10.2 finding the emf between the ends of the series connected coil

```
1  clc
2  clear
3
4  //input
5  p=4; //number of poles
6  n=48; //number of slots
7  b=0.02; //flux per pole in weber
8  w=50*(%pi); //angular velocity in rad/sec
9
10 //calculations
11 f=(w*(p/2))/(2*%pi); //frequency in hertz
12 phim=360/n; //mechanical angle in degrees
13 phie=phim*(p/2); //electrical angle in degrees
14 phiE=phie*(%pi/180); //electrical angle in radians
15 kd=(sin(2*(phiE/2)))/(2*sin(phiE/2)); //distribution
    factor and 2 is taken as we are calculating for 2
    coils
16 e=(p/2)*kd*4.44; //total e.m.f. for two coils in
    series in volts
17
18 //output
19 mprintf('the total e.m.f. for two coils in series is
    %3.1f V',e)
```

Scilab code Exa 10.3 calculation of phase and line voltages

```
1  clc
2  clear
3
4  //input
```

```

5 p=6; //number of poles
6 n=72; //number of slots
7 n1=10; //conductors per slot
8 b=0.01; //flux per pole in weber
9 f=50; //frequency in hertz
10 phi=170; //pitch of coil in electrical degrees
11 kf=1.11; //form factor for sinusoidal forms
12
13 //calculations
14 n2=n/p; //number of slots per pole
15 n3=n2/3; //number of slots per pole per phase for 3
    phase system
16 phim=360/n; //mechanical angle between slots in
    degrees
17 phie=phim*(p/2); //electrical angle in degrees
18 phiE=phie*(%pi/180); //electrical angle in radians
19 kd=(sin(n3*(phiE/2)))/(n3*sin(phiE/2)); //
    distribution factor
20 phis=(180-phi)*(%pi/180); //coil span factor in
    radians
21 kc=cos(phis); //pitch factor in radians
22 e=2*kd*kc*kf*f*b*((n*n1)/3); //e.m.f. per phase in
    volts
23 vl=(3^0.5)*e; //line voltage for star connection in
    volts
24
25 //output
26 mprintf('the phase and line voltages are %3.0f V and
    %3.0f V respectively ',e,vl)

```

Scilab code Exa 10.4 calculation of torque produced

```

1 clc
2 clear
3

```

```

4 //input
5 p=4;//number of poles
6 n1=3;//number of phases
7 f=50;//frequency in hertz
8 inp=60;//input to the motor in kW
9 l=0.06;//losses in per units
10
11 //calculations
12 w=2*pi*(f/(p/2));//angular velocity in rad/sec
13 t=(inp*1000)/w;//total torque produced in newton
    meter
14 tu=t-(t*l);//useful torque in newton meter
15
16 //calculations
17 mprintf('the total torque and the useful torque of
    the machine are %3.0f Nm and %3.0f Nm
    respectively ',t,tu)

```

Scilab code Exa 10.5 determination torque produced

```

1 clc
2 clear
3
4 //input
5 p=2;//number of poles
6 v=415;//3 phase supply voltage in volts
7 n=3;//number of phases
8 x=0.6;//reactance of phase in ohms
9 f=50;//supply frequency in hertz
10 e=0.08;//resultant e.m.f. is 0.08of supply voltage
11
12 //calculations
13 e1=(e*v)/(3^0.5);//resultant e.m.f. per phase in
    volts
14 i=e1/x;//current per phase in current

```

```

15 il=i; //line current in amperes
16 phi=(180/%pi)*atan(e); //load angle in degrees
17 the=(180-phi)/p;
18 PHI=cos(atan(e)); //power factor
19 inp=(3^0.5)*v*PHI*il; //power input in watts
20 t=inp/(2*%pi*(f/(p/2))); //torque in newton meter
21
22 //output
23 mprintf('the total torque produced is %3.0f Nm',t)

```

Scilab code Exa 10.6 finding the slip speed and the slip

```

1 clc
2 clear
3
4 //input
5 n=3; //number of phases
6 f=50; //frequency in hertz
7 w=96*(%pi); //angular velocity in rad/sec
8
9 //calculations
10 ws=(2*%pi*f)-w; //slip speed in rad/sec
11 s=ws/(2*%pi*f); //slip in per units
12
13 //output
14 mprintf('the slip speed is %3.2f rad/s and the slip
        is %3.2f p.u.',ws,s)

```

Scilab code Exa 10.7 finding the rotor speed and the frequency of rotor components

```

1 clc
2 clear
3

```

```

4 //input
5 p=6;//number of poles
6 n=3;//number of phases
7 f=50;//frequency in hertz
8 s=0.03;//slip in per units
9
10 //calculations
11 w=(2*%pi*f*60)/(n*2*%pi);//synchronous speed in rev/
    min
12 ws=s*w;//slip speed in rev/min
13 wr=w-ws;//rotor speed in rev/min
14 fs=(ws*n)/60;//frequency of rotor currents in
    amperes
15
16 //output
17 mprintf('the rotor speed will be %3.0f rev/min and
    the frequency of rotor currents will be%3.1f Hz',
    wr,fs)

```

Scilab code Exa 10.8 calculation of slip rotor copper loss total torque and the ef

```

1 clc
2 clear
3
4 //input
5 p=4;//number of poles
6 f=50;//supply frequency in hertz
7 n=3;//number of phases
8 w=1440;//speed in rev/min
9 sl=1.5;//stator losses in kW
10 fl=1.2;//friction losses in kW
11 inp=60;//input to motor in kW
12
13 //calculations
14 N=(inp*f)/(p/2);//synchronous speed in rev/min

```



```

15 ns=N-w;//slip speed in rev/min
16 s=ns/N;//slip in per units
17 rinp=inp-sl;//rotor input in kW
18 rc=s*rinp;//rotor copper losses in kW
19 tr=(rinp*1000)/((N*2*%pi)/60);//rotor torque in
    newton meter
20 rout=rinp-rc;//rotor output in kW
21 mout=rout-fl;//motor output in kW
22 eff=mout/inp;//efficiency of rotor in per unit
23
24 //output
25 mprintf('the slip is %3.2f p.u.:the rotor copper
    loss is %3.2f kW: the total torque is %3.0f Nm
    and the efficiency is %3.3f p.u.',s,rc,tr,eff)

```

Scilab code Exa 10.9 calculation of rotor copper loss and the input and efficiency

```

1 clc
2 clear
3
4 //input
5 p=6;//number of poles
6 f=50;//frequency in hertz
7 n=3;//number of phases
8 t=160;//total torque in newton meter
9 fs=120;//slip frequency in cycles/min
10 tf=12;//torque lost in friction
11 sl=750;//stator losses in watts
12
13 //calculations
14 s=fs/(60*f);//slip in per unit
15 w=(2*%pi*f)/n;//speed of motor in rad/sec
16 wr=w*(1-s);//rotor speed in rad/sec
17 rinp=t*w;//rotor input in watts
18 rc=s*rinp;//rotor copper losses in watts

```

```
19 sinp=rinp+s1;//stator input in watts
20 Sinp=sinp/1000;//stator input in kilowatts
21 tout=t-tf;//output torque in newton meter
22 pout=tout*wr;//power output in watts
23 eff=pout/sinp;//efficiency in per unit
24
25 //output
26 mprintf('the rotor loss is %3.0fW, the input to the
    motor is %3.2f kW and the motor efficiency is %3
    .2f p.u. ',rc,Sinp,eff)
```

Chapter 11

electronics

Scilab code Exa 11.1 determination of anode slope resistance the mutual conductance

```
1  clc
2  clear
3
4  //input
5  va=120; //anode voltage in volts
6  vg1=-1; //grid voltage in volts
7  vg2=-2; //grid voltage for which another curve is
           drawn in volts
8  //given scale is vertical scale: anode current 1mm
           =0.00025A and horizontal scale : anode voltage 1
           mm=2.5V
9  //from VI characteristics
10 i=0.00025; //current in amperes
11 v=2.5; //voltage in volts
12 CD=4;
13 BD=9;
14 EF=34;
15 CE=14.5;
16 //calculations
17 ra=(CD*v)/(BD*i*1000); //anode slope resistance in
           kilo ohms
```

```

18 gm=(EF*i*1000)/(vg1-vg2); //mutual conductance in
    millisiemens
19 u=(CE*v)/(vg1-vg2); //amplification factor
20
21 //ouput
22 mprintf('at the operational point the parameters of
    the valve are %3.2f kohms,%3.1f mS and %3.2f.',ra
    ,gm,u)

```

Scilab code Exa 11.2 determination of the triode parameters

```

1  clc
2  clear
3
4  //input
5  va1=125; //anode voltage in volts
6  va2=100; //anode voltage in volts for which another
    curve is obtained
7  vg1=0; //grid voltage in volts
8  vg2=-1; //grid voltage in volts
9  //given scale is vertical scale: anode current lmm
    =0.0002A and horizontal scale : anode voltage lmm
    =0.1V
10 v=0.1; //voltage in volts from scale
11 //from given data
12 //for vg1 and va2
13 ia11=4.8; //current in milli amperes
14 ia12=3.2; //current in milli amperes
15 //for vg2 and va1
16 ia21=6.625; //current in amperes
17 ia22=5.0; //current in amperes
18
19 //calculations
20 ra=(va1-va2)/(ia21-ia11); //anode slope resistance in
    kilo ohms

```

```

21 gm=(ia21-ia22)/(vg1-vg2); //mutual conductance in
    millisiemens
22 u=(va1-va2)/(v-vg2); //amplification factor
23
24 //ouput
25 mprintf('at the operational point the parameters of
    the valve are %3.1f kohms,%3.3f mS and %3.1f.',ra
    ,gm,u)

```

Scilab code Exa 11.3 finding the required anode voltage

```

1  clc
2  clear
3
4  //input
5  ia=0.002; //anode current in amperes
6  rl=5000; //resistance in ohms
7  vht=100; //anode voltage in volts
8
9  //calculations
10 va=vht-(ia*rl); //next anode voltage in volts to plot
    the characteistic curve
11
12 //output
13 mprintf('the next required anode voltage for
    plotting characteristic curve is %3.0fV',va)

```

Scilab code Exa 11.4 determination of operating points

```

1  clc
2  clear
3
4  //input

```

```

5 vht=100;//higher threshold voltage in volts
6 r11=5;//resistance of load in kilohms
7 r12=10;//load resistance in kilohms
8
9 //calculations
10 //for r11
11 //when va=0
12 ia1=vht/r11;//anode current in milliamperes
13 //when va=100
14 ia2=0;//since va=vht
15 //for r12
16 //when va=0
17 ia3=vht/r12;//anode current in milliamperes
18 //when va=100
19 ia4=0;//since va=vht
20 //two load lines are drawn on VI graph which
    coincides the anode characteristic curve at four
    points
21 //using the data given
22 //point 1
23 vg1=0;//grid voltage in volts
24 va1=71;//anode voltage in volts
25 i1=5.9;//anode current in milliamperes
26 //point 2
27 vg2=-2;//grid voltage in volts
28 va2=79;//anode voltage in volts
29 i2=4.3;//anode current in milliamperes
30 //point 3
31 vg3=0;//grid voltage in volts
32 va3=57;//anode voltage in volts
33 i3=4.3;//anode current in amperes
34 //point 4
35 vg4=-2;//grid voltage in volts
36 va4=68;//anode voltage in volts
37 i4=3.2;//anode current in amperes
38
39 //output
40 mprintf('for a load of 5kilohm ,the operating points

```

are \n $v_g = 3.0 \text{ fV}$: $v_a = 3.0 \text{ fV}$ $i_a = 3.1 \text{ fA}$ \n $v_g = 3.0 \text{ fV}$: $v_a = 3.0 \text{ fV}$ $i_a = 3.1 \text{ fA}$ \n for a load of 10 kilohms, the operating points are \n $v_g = 3.0 \text{ fV}$: $v_a = 3.0 \text{ fV}$ $i_a = 3.1 \text{ fA}$ \n $v_g = 3.0 \text{ fV}$: $v_a = 3.0 \text{ fV}$ $i_a = 3.1 \text{ fA}$ ', $v_{g1}, v_{a1}, i_1, v_{g2}, v_{a2}, i_2, v_{g3}, v_{a3}, i_3, v_{g4}, v_{a4}, i_4$)

Scilab code Exa 11.5 finding the voltage amplification

```

1  clc
2  clear
3
4  //input
5  g=4; //mutual conductance of a triode in millisiemens
6  u=25; //amplification factor
7  l=20; //load in kilo ohms
8
9  //calculations
10 ra=u/g; //slope resistance in kilo ohms
11 av=(u*l)/(ra+l); //voltage gain
12
13 //output
14 mprintf('with a load resistance of 20 kilo ohms this
           triode will give a voltage amplification of %3.2f
           ',av)

```

Scilab code Exa 11.6 determination of ac voltage across the load

```

1  clc
2  clear
3
4  //input
5  rc=50; //resistance of the coil in ohms

```

```

6 lc=0.0005; //inductance of the coil in henry
7 //coil is connected in parallel with a capacitor
8 fr=0.5*(10^6); //resonance frequency in hertz
9 vl=1.5; //voltage across the load in volts
10 rs=50000; //slope resistance in ohms of the triode
11 u=25; //amplification factor of the triode
12
13 //calculations
14 c=(lc*(10^12))/((rc^2)+(2*pi*fr*lc)^2); //
    capacitance in picofarad
15 rl=(lc*(10^9))/(rc*c); //resistance of load in
    kilohms
16 a=(u*rl)/(rc+rl); //voltage amplification
17 e0=a*vl; //a.c. voltage across load in volts
18
19 //output
20 mprintf('at a frequency of 0.5MHz the a.c. voltage
    across the load will be %3.1fV in antiphase to
    the 1.5V in the grid circuit',e0)

```

Scilab code Exa 11.7 calculation of input resistances

```

1 clc
2 clear
3
4 //input
5 ib1=-50; //base current in micro amperes
6 vce1=0; //emitter collector voltage in volts
7 ib2=-25; //base current in microamperes
8 vce2=6; //emitter collector voltage in volts
9 //locate a point at vce=0V and Ib=-50uA and draw
    tangent to it.
10 //from tangent co-ordinates
11 a1=150;
12 a2=87.5;

```



```

13 a3=75;
14 a4=25;
15 //locate a point at vce=6V and Ib=-25uA and draw a
    tangent to it.
16 //from the tangent co-ordinates
17 vbe1=200;//base emitter voltage in millivolts
18 vbe2=100;//base emitter voltage in millivolts
19 vbe3=50;//base emitter voltage in millivolts
20 vbe4=0;//base emitter voltage in millivolts
21
22 //calculations
23 ri=((a1-a2))/(a3-a4);//input resistance in kilo ohms
24 Ri=(vbe1-vbe2)/(vbe3-vbe4);//input resistance in
    kilo ohms
25
26 //output
27 mprintf('the input resistances for the specified
    conditions are %3.2f kilo ohms and %3.0f kilo
    ohms.',ri,Ri)

```

Scilab code Exa 11.8 determination of output resistances

```

1 clc
2 clear
3
4 //input
5 ib1=-100;//base current in micro amperes
6 vce1=10;//emitter collector voltage in volts
7 ib2=-50;//base current in microamperes
8 vce2=25;//emitter collector voltage in volts
9 //locate a point at vce=10V and Ib=-100uA and draw
    tangent to it.
10 //from tangent co-ordinates
11 a1=20;
12 a2=5;

```

```

13 a3=5.22;
14 a4=4.55;
15 //locate a point at vce=25V and Ib=-50uA and draw a
    tangent to it.
16 //from the tangent co-ordinates
17 vbe1=30;//base emitter voltage in millivolts
18 vbe2=20;//base emitter voltage in millivolts
19 vbe3=3.65;//base emitter voltage in millivolts
20 vbe4=2.9;//base emitter voltage in millivolts
21
22 //calculations
23 r0=((a1-a2))/(a3-a4);//input resistance in kilo ohms
24 R0=(vbe1-vbe2)/(vbe3-vbe4);//input resistance in
    kilo ohms
25
26 //output
27 mprintf('the output resistances for the specified
    conditions are %3.1f kilo ohms and %3.1f kilo
    ohms.',r0,R0)

```

Scilab code Exa 11.9 finding the parameters of the operating points

```

1  clc
2  clear
3
4  //input
5  ib=-10;//base current in microamperes
6  r1=6;//load resistance in kilo ohms
7  v=30;//supply voltage in volts
8
9  //calculations
10 //when vce=0V
11 ic=v/r1;//collector current in milliamperes
12 //whenic=0mA
13 vce=v;//collector emitter voltage in volts

```

```

14 //line AB where A(Vce=0V,Ic=5mA) and B(Vce=30V,Ic=0
    mA) cuts characteristic curve at point P
15 //from co-ordinates of P
16 Vce=16;//collector emitter voltage in volts
17 Ic=2.4;//collector current in milliamperes
18 ie=Ic+(-ib/1000);//emitter current in amperes
19
20 //output
21 mprintf('the parameters of the operating point under
    the conditions specified are Vce=%3.0fV,Ic=%3.1
    fmA and Ie=%3.2f mA',Vce,Ic,ie)

```

Scilab code Exa 11.10 calculation of current gain

```

1 clc
2 clear
3
4 //input
5 rl=10;//load resistance in kilohms
6 //for Ie= 0 ,0.8,2.0,2.8,4.0 Ic
    =0,0.78,1.95,2.73,3.9 respectively in mA
7 //taking any two set of values
8 ic1=3.9;
9 ic2=0;
10 ie1=4;
11 ie2=0;
12
13 //calculations
14 cg=(ic1-ic2)/(ie1-ie2);//current gain
15
16 //output
17 mprintf('the current gain is %3.3f',cg)

```

Scilab code Exa 11.11 determination of collector emitter voltage and current gain

```
1 clc
2 clear
3
4 //input
5 //from the characteristics when Vce=15V
6 ic1=5; //collector current in milli amperes
7 ic2=2.8; //collector current in milli amperes
8 ib1=100; //base current in micro amperes
9 ib2=50; //base current in micro amperes
10
11 //calculations
12 b=((ic1-ic2)*1000)/(ib1-ib2); //current gain
13
14 //output
15 mprintf('when the collector-emitter voltage is 15V
    the current gain is %3.0f',b)
```

Scilab code Exa 11.12 calculation of voltage and current gains

```
1 clc
2 clear
3
4 //input
5 rl=2.5; //resistance of load in kilo ohms
6 //from VI charecteristic curves
7 //for bias current of -10uA
8 vce1=21; //in volts
9 ic1=3.6; //in mA
10 ib1=-10; //in uA
11 //for bias current of -15uA
12 vce2=14.75; //in volts
13 ic2=6; //in mA
14 ib2=-15; //in uA
```

```

15 //from input characteristic curve
16 vbe1=0.75;
17 vbe2=0.45;
18 Ib1=40;
19 Ib2=0;
20
21 //calculations
22 b=((-ic2-(-ic1))*1000)/(ib2-ib1); //current gain
23 s=(vbe1-vbe2)/(Ib1-Ib2); //slope of curve
24 S=s*5; //for change in 5mV
25 v=(vce1-vce2)/S;
26
27 //output
28 mprintf('the voltage and current gains are %3.0f and
          %3.0f ',v,b)

```

Scilab code Exa 11.13 calculation of voltage gain

```

1  clc
2  clear
3
4  //input
5  b=50; //current gain
6  rl=10; //load resistance in kilo ohms
7  rint=6.5; //internal resistance of an alternating
          source in kilo ohms
8  rinp=1; //input resistance in kilohms
9
10 //calculations
11 v=(rl*b)/(rint+rinp); //voltage gain
12
13 //output
14 mprintf('the voltage gain under given conditions
          will be %3.0f ',v)

```

Scilab code Exa 11.14 finding voltage gain when h parameters are given

```
1  clc
2  clear
3
4  //input
5  //given h-parameters of a junction transistor
6  hie=1000;//in ohms
7  hoe=100*(10^-6);//Sec
8  hre=0.0005;
9  hfe=50;
10 rl=10000;//load resistance in ohms
11
12 //calculations
13 Yt=hoe+(1/rl);
14 v=(1/((hie*(-Yt/hfe))+hre));//voltage gain and -
    signifies the 180 degree phase shift
15 vg=-v;
16 //output
17 mprintf('the voltage gain would be %3.0f',vg)
```

Scilab code Exa 11.15 calculation of required load resistance

```
1  clc
2  clear
3
4  //input
5  //given h-parameters of a junction transistor
6  hie=1000;//in ohms
7  hoe=100*(10^-6);//Sec
8  hre=0.0005;
9  hfe=50;
```

```
10 cg=30; //current gain
11
12 //calculations
13 yl=(cg*hoe)/(hfe-cg); //load admittance in kilo mho
14 rl=1/(yl*1000); //load resistance in kilo ohms
15
16 //output
17 fprintf('to give a current gain of 30 the load would
    have to have a resistance of %3.2f kilo ohms',rl
    )
```
